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Aggregate Resources Inventory of the North Bay Area Districts of Nipissing and Parry Sound Northern Ontario

By Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1984

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

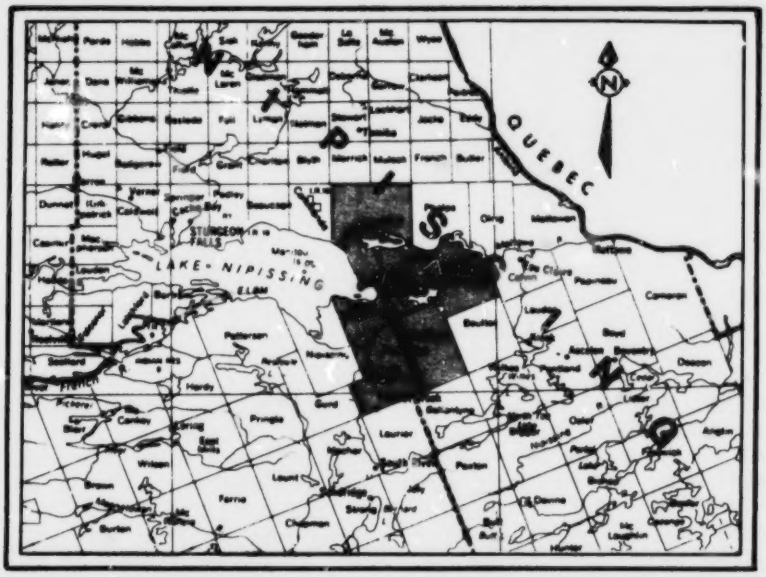

Figure 1 - Key Map Showing the Location of the North Bay Area, Scale 1:1 800 000.

This report includes an inventory and evaluation of sand and gravel, as well as bedrock resources in the City of North Bay and five surrounding townships in the Districts of Parry Sound and Nipissing (Figure 1). The report is based on previous studies in the area and on detailed field assessment undertaken in the summer of 1980 by a two-man field party funded by the Ontario Ministry of Northern Affairs.

A total of fourteen sand and gravel deposits in the project area have been identified as important aggregate sources and have been selected as resource areas of primary significance. The resource areas occupy a total of 11,800 acres (4800 ha), of which an estimated 9300 acres (3750 ha) are currently available for extraction. The total sand and gravel resource tonnage is estimated to be 600 million tons (540 million tonnes). Good-quality crushable gravel is available in parts of three esker-outwash complexes in the City of North Bay, a large esker in Bonfield Township and several eskers in the southern portion of Chisholm Township. Sand resources are available in other areas of primary significance and in extensive areas of secondary significance in Chisholm, South Himsworth, North Himsworth, and Bonfield Townships.

Extractive activity in the project area has been concentrated in the three large resource areas in the City of North Bay, and to a lesser extent in the Bonfield esker. Extraction in the rest of the area has been largely small-scale and for local use. Estimated resources of crushable gravel will be sufficient for the near future. However, in the long term, resources of bedrock-derived crushed stone may become more important, especially in the aggregate-poor, thinly drift-covered, central portion of the North Bay area, south of Trout Lake.

The project area is underlain predominantly by metamorphosed granites, monzonites and metasedimentary gneisses of the Precambrian Shield. Drift cover is generally thin and irregular. The granites and monzonites are generally considered the most likely rock types in the North Bay area to provide suitable material for the production of crushed aggregate.

Several areas of bedrock covered by thin drift have been selected for possible resource protection. The resource areas occupy a total of 41,000 acres (16 600 ha), of which an estimated 37,000 acres (15 000 ha) are presently available for extraction. Based on an estimated quarriable thickness of 60 feet (18 m), possible bedrock resources are approximately 8200 million tons (7400 million tonnes). These areas may be suitable for large-scale quarry development. Bedrock quarries may become significant in the North Bay area in the long term, when resources of natural crushable gravel are exhausted.

Selected resource areas are not intended to be permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE NORTH BAY AREA[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1980, the total tonnage of mineral aggregates extracted was 171 million tons (155 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1981).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

[1]Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, February 25, 1984.
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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg) units from existing pit faces or from test pits dug by backhoe. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, 9- to 15-foot (3 to 5 m) sections were excavated using a backhoe. The sediments revealed in these test holes were described and bulk samples were taken to better assess the potential of the deposit. The symbols for and locations of sample and test hole sites are noted on Map 1.

In the office, the field data were supplemented by pit information on file with the Soils and Aggregate Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent,

assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted. The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 25 feet (8 m) of unconsolidated overburden is determined from bedrock geology maps and from the interpretation of available subsurface data. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the rock unit. In most cases a standardized estimate of a quarriable thickness of 60 feet (18 m) is used. Although the thickness of the Precambrian bedrock units in northern Ontario are all probably considerably greater, the 60-foot (18-m) value is considered an appropriate estimate of the maximum thickness of material that can be economically and technologically extracted from a given quarry face. Volume estimates are then multiplied by 3700 (the estimated weight, in Imperial tons, of a one-foot (0.3-m) thick section of Precambrian rock one acre (0.4 ha) in extent, assuming a bulk density of 170 pounds per cubic foot (2729 kg per cubic metre)).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregate are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

For each map area there are three maps, each portraying a different aspect of the aggregate resources in the study area, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resources Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock lithologies, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

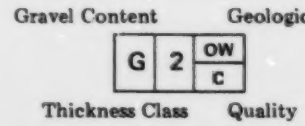
Map 1 is derived directly from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. It shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Pits are shown by a solid dot and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner and location of the pit, as well as the estimated face height, and percentage gravel.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the sub-

division of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the report area and is given a deposit number which denotes its ranking order in that area. All such deposits are shown by dark red shading on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light red shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in the report area, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol of each deposit on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content, (G or S), indicates the suitability of aggregate for various

uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (or high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas, because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the

local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology maps, water well data from the Ontario Ministry of the Environment, drilling assessment data from the Ontario Ministry of Natural Resources and from the Northern Ontario Engineering Geology Terrain Studies produced for the Ontario Geological Survey. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Areas where bedrock outcrops, or is within 3 feet (1 m) of the ground surface are indicated by dark blue shading. Isolated bedrock outcrops which lie outside these areas are indicated by a black "X" symbol. These areas constitute potential resource areas of primary significance, because of their easy access. Areas where the bedrock is covered by 3 to 25 feet (1 to 8 m) of drift are indicated by light blue shading. Quarrying is possible in this depth of overburden and these also represent potential resource areas. Outside the delineated areas of thin drift cover, the bedrock is generally overlain by more than 25 feet (8 m) of drift. These areas constitute resources which have extractive value only in specific circumstances and it is unlikely these areas will constitute resource areas of economic significance.

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. All known quarries are shown by a dot symbol and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location and an estimate of face height. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics of the bedrock units found in the study area are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Two factors support this approach. First, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and second, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances

can be considered. These factors allow the identification of alternative sites having similar development potential. The selected areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

It should be stressed, that the Precambrian Shield rocks in northern Ontario are generally more complex and variable than the Paleozoic rocks of southern Ontario. They often show wide variations in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for hot-laid asphaltic and road-base material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, the total area selected as a bedrock resource should not be considered acceptable for aggregate use. They are, however, areas in which the probability of finding a supply of acceptable aggregate is considered most likely.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a Resource Area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE NORTH BAY AREA

LOCATION AND POPULATION

The area described in this report includes the City of North Bay and five surrounding townships. The location and extent of the project area are shown in Figure 1. The area is included on the North Bay (31 L/6), Powassan (31 L/3) and South River (31 E/14) sheets of the National Topographic System at a scale of 1:50 000.

The City of North Bay occupies an irregular area of 77,180 acres (31 235 ha) on the eastern shore of Lake Nipissing. The present boundaries of the city were formed in 1976 by the amalgamation of the former geographic townships of Widdifield and West Ferris, and are shown on Maps 1A, 2A, and 3A. The total population of the City of North Bay was 50,567 in 1982 and earlier figures indicate that the population has increased by 9 percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Although the growth rate of the city itself has been relatively low, significant population increases have occurred in rural townships within commuting distance of the city. Severance and subdivision applications have increased in these areas and considerable rural-residential development has occurred (Proctor, Redfern, Bousfield and Bacon 1973).

The Townships of East Ferris, Bonfield, and Chisholm, in the District of Nipissing, are shown on Maps 1B, 2B, and 3B. These townships occupy a combined area of 142,036 acres (57 482 ha). The total population was 6184 in 1982 and past figures indicate that the population has increased by 39 percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Populated centres include the unincorporated settlements of Astorville, Bonfield and Rutherglen. Most of the population is rural and the trend to rural-residential and seasonal-recreational development, especially along the lake shores in the north, is expected to intensify. The construction of access roads, housing and services to accommodate this growth would increase local demand for all types of aggregate products.

The Townships of North Himsworth and South Himsworth, in the District of Parry Sound, occupy a combined area of 83,516 acres (33 799 ha) and are shown on Maps 1C, 2C, and 3C. In 1982, these townships had a population of 3936, which represents an increase of approximately 17 percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The main population centres in the two townships are the Towns of Powassan and Trout Creek and the unincorporated settlement of Callander. The population of the two townships is likely to increase through rural-residential and seasonal-recreational development.

Access within the project area is provided by a rectangular grid of gravel-surfaced township roads and by several paved provincial highways. King's Highway 11 runs north-south through the western part of the area and is one of the major access routes connecting northern and southern Ontario. Highway 11 intersects King's Highway 17, the Trans-Canada Highway, just south of North Bay. The area is also serviced by King's Highways 63 and 94, and by Secondary Highways 522, 531, 534, and 654. Most of the project area is accessible by road, with the exception of the rugged terrain in the northern parts of East Ferris and Bonfield Townships, in the Algonquin Highlands, and in parts of the Genesee Moraine in southern Chisholm and South Himsworth Townships.

Rail access is provided by two lines of the Canadian National Railway and one line of the Canadian Pacific Railway. One Canadian National line runs parallel to Highway 11 and the other trends southwest through Chisholm Township. The Canadian Pacific line generally runs parallel to Highway 17. In addition, a line of the Ontario Northland Railway crosses the central part of the City of North Bay.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The North Bay area lies mainly within the Nipissing-Mattawa Lowland physiographic region, although sections of the project area lie within the Northern Uplands and Algonquin Highland physiographic regions (Harrison 1972). The bedrock consists predominantly of Pre-

cambrian age monzonitic, granitic and metasedimentary rocks (Lumbers 1971). The bedrock surface is irregular, but generally of subdued relief, except at the Thibeault Escarpment at the northern edge of the City of North Bay. Drift cover is generally thin, although in places it exceeds 100 feet (30 m).

The thickness and distribution of surficial materials in the project area, including the sand and gravel deposits, are the result of extensive glacial activity which took place during the Great Ice Age (the Wisconsinan Stage of the Pleistocene Epoch). This period of time, which lasted from approximately 100 000 to 7000 years ago, was marked by the advance and then disappearance of immense, continental ice sheets.

The entire area was covered during the Wisconsinan by ice which advanced to the southeast (Harrison 1972). The limit of this advance was far to the south of the project area. During the advance, the ice deposited an extensive veneer of compact, stony sandy till. The distribution of this material is irregular and its thickness varies greatly. The fines content of the till is generally quite low (Harrison 1972), therefore the material may be suited for low-specification aggregate for road building and construction. Most of the higher specification sand and gravel resources in the project area are concentrated in moraines and eskers which were deposited at the margins of the ice mass during the retreat of the ice margin to the north at the end of the Wisconsinan.

The largest single aggregate deposit in the project area is the Genesee Moraine, located in the southern portion of Chisholm Township. The moraine generally consists of fine-grained sediment deposited in a broad, northeast-trending band. The surface of the deposit is irregular and hummocky. Local relief exceeds 200 feet (61 m) in places and well developed kettle depressions and esker ridges are common. The Genesee Moraine was formed by meltwaters flowing off the ice margin as it retreated from the Algonquin Highlands, into the Nipissing-Mattawa Lowlands. The meltwaters were confined by the ice margin and the higher land to the south, resulting in sediment being deposited in Chisholm Township, and in small morainic deposits just south of the Town of Powassan in South Himsworth Township. This ice-marginal position has been named the Genesee Outlet phase by Harrison (1972) to denote the main drainage outlet for meltwaters through Genesee Creek.

The sediments in the Genesee Moraine are predominantly sandy except for several gravelly, esker-like ridges found in the eastern portion of the deposit. The ridges contain crushable gravel which has been extracted at small pits near Wasing. Aggregate from the pits is acceptable for a range of load-bearing products. Further investigation of large expanses of bush-covered terrain in the western part of the moraine may disclose more pockets of crushable gravel.

Northward retreat of the ice margin from the Genesee Moraine uncovered the Fossmill Outlet (Harrison 1972). During this phase, meltwater ponded against the ice front may have been 300 feet (91 m) deep and may have covered most of the Nipissing-Mattawa Lowlands, in Chisholm and South Himsworth Townships. Small morainic sand and gravel deposits which may mark the ice marginal position are found on high ground at the Town of Powassan and south of the hamlet of Chiswick.

During the Fossmill Outlet phase, considerable amounts of sand and gravel were also deposited beneath the ice in a large esker system which now trends to the southwest through Bonfield Township. The Bonfield esker is a single, segmented ridge, 30 to 60 feet (9 to 18 m) high, which consists predominantly of crushable gravel. The ridge is flanked by thin outwash deposits for much of its length. At the southern end of the deposit, the gravel ridge grades into finer-grained deltaic sediments which mark the ice frontal position during the time the esker was formed. The Bonfield esker, extracted at several large pits in the past, is presently an important source of good-quality crushable gravel suited for a wide range of road-building and construction aggregate.

As the ice margin retreated from the Fossmill Outlet position, it did so at a greater rate in the western portion of the project area than in the east. This may have resulted from rapid calving of ice into the deep water ponded against the ice front in the Nipissing-Mattawa Lowlands. The ice margin in the west retreated to an east-west position along the brow of the Thibeault Escarpment, which lies north of the City of North Bay and the Town of Trout Lake. The glacial lake ponded against the ice

margin in this area covered most of North and South Himsworth and East and West Ferris Townships. At Rutherglen in Bonfield Township, the ice margin curved southward and water drained eastwardly through the Sobie-Guillemette Outlet (Harrison 1972). Sand and gravel were deposited at the ice margin and formed a large, north-south trending ridge named the Rutherglen Moraine (Harrison 1972). The moraine is a broad, irregular, segmented ridge with hummocky topography and local relief of more than 150 feet (46 m) in places. Several small pits in the southern portion of the moraine expose predominantly sandy material, while in the north, considerable amounts of crushable gravel are exposed in irregular pockets and lenses in the sand. Flanking the western side of the moraine, is a broad outwash apron which was deposited in shallow water ponded against the moraine. This material decreases rapidly in grain size to the west and may have limited value as aggregate.

While the western part of the ice margin was situated at the Thibeault Escarpment, considerable amounts of sediment were deposited in three, parallel, southward-flowing, subglacial meltwater streams. These deposits lie in the geographic township of Widdifield and extend from the northern boundary of the township to the edge of the escarpment. The northern portions of the deposits consist of well-defined, segmented esker ridges composed predominantly of pebble and cobble gravel. These parts of the central and western deposits are presently being extracted at several large commercial pits. The eastern deposit is relatively unexploited at present, and may represent a valuable aggregate source for the North Bay area. In the middle portions of the deposits, the coarse aggregate of the eskers is generally overlain by or grades into slightly finer-grained outwash. This material was deposited during a later period of open channel flow after considerable melting occurred at the ice margin. Many large pits have been opened in the middle portions of the central and western deposits, and these pits have supplied much of the road-building and construction aggregate used in the City of North Bay. The southern portions of the deposits are extensive sandy deltaic sequences which were deposited in deep water ponded against the Thibeault Escarpment. The aggregate in these areas consists of well sorted sand and silt. Several pits have been opened in the southern parts of the deposits, but are able to supply only a limited range of fine aggregate products.

Following the Sobie-Guillemette Outlet phase, the ice margin retreated beyond the northern boundaries of the North Bay area. Considerable amounts of meltwater covered much of the area for a brief period of time until the uncovering of new drainage routes allowed much of the water to drain eastward into the Ottawa River valley, marking the end of glacial activity in the area. Postglacial erosional and depositional processes have been of relatively minor importance in modifying the physiography. The present land surface still strongly bears the imprint of glacial activity.

EXTRACTIVE ACTIVITY

Although more than 150 sand and gravel pits have been opened in the North Bay area, many sources have been abandoned or have been inactive for a considerable period of time. During the field work for this study, 67 pits were observed to be active or to have been used in the recent past. Most of these sources were active on a demand basis using portable extraction and processing equipment. These sources supply most of the aggregate needs for the rural townships surrounding the City of North Bay. There are only four large commercial pits in the North Bay area which have permanent processing facilities and which operate on a continuing basis. Most of these sources are located in the City of North Bay, and supply a wide range of high-specification products for road-building and construction in the city.

The general textural and lithologic qualities of the sand and gravel deposits in the North Bay area are quite good. The coarse aggregate in most of the deposits is derived from Precambrian bedrock formations which are generally considered suitable for load-bearing products. The only quality limitations occur in areas where large amounts of oversize clasts are present or in areas where coarse-grained gneissic rocks make up a large proportion of the aggregate. In the latter case, the rock types are susceptible to rapid weathering and have poor load-bearing characteristics. This may be a problem in parts of the Bonfield esker (Z.L. Katona, Senior Soils and Aggregates Engineer, Ontario Ministry of Transportation and Communications, Downsview, personal communication, 1980). Prolonged stockpiling of the aggregate allows the weathering of the weaker clasts

which may then be removed by additional screening.

The low proportion and variable occurrence of gravel, throughout the project area poses problems in the production of crushed aggregate. Gravel is plentiful only in the northern portions of the esker complexes in the City of North Bay, in the Bonfield esker, and in parts of the Genesee Moraine. Although further resources of gravel are available in these deposits, they are presently being extracted at an accelerated rate and gravel may be scarce in the near future.

Other sources of crushable aggregate in the project area are ice-contact stratified drift deposits of esker or morainic origin. These are generally small and scattered throughout the area. Many small pits have been opened in these deposits, usually in local pockets of gravel. These local operations are of a "high grading" type and are often abandoned after the gravel has been removed. Generally, the gravel content is irregular and variable in the deposits and selection and sand control are required to produce high- specification products. Further field investigation may reveal other pockets of crushable gravel within these deposits.

Resources of sand, however, are plentiful and many sand pits have been opened. Small pits have been developed in extensive sandy outwash and ice-contact stratified drift deposits scattered throughout the area. These pits have supplied low-specification products such as sand cushion and fill for local use as well as small amounts of higher-specification products. Most of these pits have been worked on a demand basis and are presently abandoned or inactive. The numerous, thin, but extensive sand deposits of outwash or lacustrine origin in the area are generally too fine grained to be used for aggregate.

Several large pits have been opened in the sandy deltaic deposits which form the southern portions of the esker complexes in the City of North Bay. A number of these pits have permanent processing plants and produce large amounts of blending sand for hot-laid asphaltic and concrete aggregate. Large possible resources of this material are still available in these deposits, although excess amounts of fines severely limits the uses of the sand in some places.

SELECTED SAND AND GRAVEL RESOURCE AREAS: CITY OF NORTH BAY

All three of the north-south trending esker complexes in the northern portion of the City of North Bay have been selected for possible resource protection at the primary level.

The three deposits contain large quantities of good-quality aggregate and are strategically very important as they contain virtually all of the city's available resources of crushable gravel. The northern portions of the deposits consist of well developed, esker ridges with sandier material deposited on their flanks and in intervening depressions. Southwards, the deposits consist of coarser outwash gravel deposited in a generally sandy outwash plain. Pits have been developed in the central portions of all three deposits. At the southern end of the three resource areas, large deltas mark the point where the outwash streams emptied into glacial lakes ponded against the ice margin. These deltas are predominantly sandy, and have been extracted at several large pits for the production of fine-grained aggregate.

The portions of the three deposits which have been selected for possible protection at the primary level occupy a total of 6000 acres (2430 ha), of which 3950 acres (1600 ha) are estimated to be presently available for extraction. Based on an estimated thickness for each of the areas, the total available resources are approximately 240 million tons (218 million tonnes).

Portions of the three resource areas have been selected as Sand and Gravel Resource Areas of Secondary Significance. The Areas of Secondary Significance contain relatively small amounts of material, and have quality limitations. However, consideration should be given to the inclusion of these areas in resource management strategies as the material may be acceptable for local projects, or in cases where better material is unavailable for extraction.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is the westernmost of the three resource areas and lies along Highway 11 in the northern part of the city. Area 1 is the largest and best developed of the three areas and probably contains the greatest proportion of crushable aggregate. The resource area has been divided into smaller areas

based on thickness and gravel content. The smaller areas are identified by a letter after the number on Map 2A and on Table 3 for the City of North Bay.

Resource Area 1a is situated north of the Duchesnay River. It consists of a single, large, esker ridge which has only partially been buried by later deposition. The ridge varies in width from 490 to 3450 feet (150 to 1050 m) and has maximum local relief of 120 feet (37 m). Three large pits (pits 1, 2, and 3) have been opened in this part of the deposit and all are presently active. Two other large pits (pits 18 and 19) are now inactive and are nearly depleted. The active pits have face heights ranging from 15 to 30 feet (5 to 9 m) and expose poorly sorted, coarse pebble to cobble gravel, in a coarse sand matrix. The coarse material is occasionally interlayered with sandy cross-stratified units, and in places grades into extensive fine-grained sediments. Samples of the coarse aggregate in this area (pit 2 (2 samples) and pit 3; Figure 2a) contain 55 to 80 percent gravel. Coarse units dominate most of the exposed faces in the active pits and the gravel is processed on the site by portable crushing and screening equipment to produce a wide range of road-building and construction products. The aggregate is acceptable for Granular Base Course (G.B.C.) A and B, 16 mm crushed stone, concrete aggregate, and Hot-Laid (H.L.) Nos. 4 to 8 asphaltic aggregate, as well as lower specification products, such as G.B.C. C and sand cushion. The amount of crushable gravel in Area la is variable, with the highest content in the ridge itself. In areas containing coarse material, oversize stones with dimensions up to 3 feet (1 m) are common, and require primary crushing. Sandy material may also be encountered in the ridge and selection and sand control may be required.

Away from the central ridge, Area 1a contains predominantly sandy aggregate. A sample was taken from an entirely fine-grained section of pit 3. The sand grades fine and contains significant amounts of silt-sized material in thin beds interlayered with laminated fine sand and some coarse cross-stratified sand. Silt sections should be avoided for the production of hot-laid asphaltic aggregate, but higher silt contents are acceptable for lower specification products such as sand cushion, fill and G.B.C. C. During field investigation, a portable asphalt plant was operating at pit 2.

Although considerable amounts of gravel have been removed from Area 1a, large resources of good-quality gravel still remain. The area occupies a total of 340 acres (138 ha). One hundred and ninety acres (77 ha) have previously been extracted and 20 acres (8 ha) are unavailable for extraction because of other development. Approximately 130 acres (53 ha) are presently available for extraction. Assuming an average deposit thickness of 25 feet (8 m), currently available sand and gravel resources are estimated to be 8 million tons (7 million tonnes).

Further to the south in Resource Area 1, the esker ridge has been buried by younger, finer-grained outwash deposits. The general limits of this partially buried portion of the esker are shown as Area 1b on Map 2A. To the east and south of the North Bay Sanatorium, coarse esker gravel has been extracted in two deep pits (pits 4 and 23). Pit 4 is presently active and has several deep sections with face heights in excess of 60 feet (18 m). A dragline has been used in the past to extract material from below the water table, however, present extraction is done by conventional methods. The gravel is suitable for G.B.C. A and B and for H.L. 4 to 8. The material is crushed for the production of concrete aggregate and for concrete blocks which are produced on the site. The pit is nearly depleted of crushable gravel, although pockets may remain. Area 1b occupies a total of 150 acres (61 ha), but because of extensive previous extraction, only 35 acres (14 ha) are presently available for possible development. Assuming an average deposit thickness of 45 feet (14 m), presently available sand and gravel resources are estimated to be 4 million tons (4 million tonnes). Coarse aggregate may underlie sand in several parts of Area 1b. However, detailed field investigation will be required to identify specific areas.

Resource Area 1c consists of outwash gravel deposited around and over the esker during a later period of flow in the system. The ice margin had retreated considerably at this time and formed a broad, ice-walled channel in which a complex braided stream sequence of sand and gravel was deposited. The outwash flanks the western side of Area 1b and completely covers earlier deposits in the mid-portions of Resource Area 1. Two active pits (pits 5 and 12) and several small inactive sources (pits 20, 24, and 31) have been opened in Area 1c. Faces in these

pits are 12 to 30 feet (4 to 9 m) in height and expose predominantly cross-stratified coarse sand with pebbly layers and occasional sections consisting of horizontally stratified gravel. One face in the northeast part of pit 5 exposes coarse, poorly sorted gravel which may form part of the buried esker ridge. Other faces in the pit expose medium to coarse, horizontally stratified sand with some gravel layers. Generally, the aggregate in Area 1c is suitable for crushing, although selection and sand control will be required and some areas are too sandy for crushing. The gravel is suitable for G.B.C. A and B and H.L. 4. The fine fraction is suitable for G.B.C. C, select subgrade material, and for H.L. 4, but in places is too fine for any use.

Although Area 1c occupies a large area of 1120 acres (455 ha), there are many cultural constraints on extraction, especially in association with development along Highway 11. These cultural setbacks reduce the area currently available for extraction to 600 acres (243 ha). Assuming an average thickness of 23 feet (7 m), presently available sand and gravel resources are estimated to be 34 million tons (31 million tonnes). The best possible sites for future extractive development may lie to the west of the Department of National Defense property in the northern portion of Area 1c and to the east of pit 24. Further investigation of the portion of Area 1c on the west side of Highway 11 may disclose additional resources of gravel.

Area 1d of Selected Resource Area 1 is the sandy delta deposited at the southern end of the esker-outwash system. The area has been extracted at several large pits in the past (pits 7, 25, 26, 27, and 29), only one of which, (pit 7) is still active. Faces in the pits range in height from 12 to 65 feet (4 to 20 m) and generally expose well sorted, horizontally stratified fine to coarse sand with some layers of pebbly sand. The upper portions of most faces and all of some faces are characterized by interlayered, fine sand and silt. This fine aggregate is generally too fine for crushing and in places, where significant amounts of silt occur, is too fine for any granular use. The aggregate has been used for hot-laid asphaltic aggregate as well as lower specification products, such as sand cushion and fill.

Coarse-grained material, including crushable gravel, was extracted at pit 25, although this pit is near depletion and has not been used for some time. The coarse aggregate was taken at depths of up to 60 feet (18 m).

Several other large pits have been opened to the south and east of pit 25 and the material was used extensively in the construction of the North Bay Airport. These pits are now abandoned and one is presently used as the city's waste disposal site.

Area 1d occupies a total of 600 acres (243 ha), of which 325 acres (132 ha) are presently available for extractive development. Assuming an average thickness of 35 feet (11 m), presently available resources of sand suitable for a limited range of products are estimated to be 28 million tons (25 million tonnes). The most promising site for future development may be to the east of pit 7.

Area 1e of Selected Resource Area 1 consists of the sandy outwash deposits located on the periphery of the northern portion of the esker-outwash system. No subsurface data are available for these portions of the resource area. However, field observations and air photo interpretation indicate that significant amounts of sandy aggregate may be available. Area 1e occupies a total of 690 acres (280 ha) of which 680 acres (275 ha) are available for extraction. Assuming an average thickness of 15 feet (5 m), presently available resources are estimated to be 26 million tons (24 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is the central deposit of the three esker-outwash complexes in the City of North Bay. Area 2 trends to the south from Caribou Lake, along the east side of the North Bay Airport to the edge of the Thibeault Escarpment.

North of Four Mile Lake, the resource area consists predominantly of a single segmented ridge flanked by thin sandy outwash deposits. The esker segments have been identified as Resource Area 2a. The northernmost segment is a single sinuous ridge with local relief of approximately 75 feet (23 m). No pits have been developed in this deposit, although possible resources of crushable gravel may be present. Several pits (pits 8, 21, 22, and 37) have been opened in the southern two segments of the Area. Pit 8 was active during field investigation, and a good cross-section of the esker ridge is

exposed in the pit face. The face is 12 feet (4 m) in height and consists of massive, poorly sorted cobble and boulder gravel with a coarse sand matrix. Many of the clasts exceed 2 to 3 feet (0.6 to 1 m) in diameter, and special primary crushing equipment is required to reduce the oversize component. The sandy aggregate which flanks the esker ridge is also exposed at pit 8 and is generally less than 15 feet (5 m) in thickness. Bedrock is exposed in parts of the pit floor. The aggregate was processed by modern portable crushing and screening equipment operated by Hoffman Concrete Ltd., and was hauled to their ready-mix plant at pit 15 (Resource Area 2b). South of pit 8, a large pit was opened (pit 21) in the esker ridge, but the gravel at this site has since been depleted. The dimensions of the esker and the grain size of the gravel are similar to that at pit 8 and, again, bedrock is exposed on the pit floor.

Pit 22, owned by Hoffman Concrete Ltd., is located at the coalescence of several esker ridges. The deposit may represent a kame-delta formed where the esker stream emptied into standing water during an early phase of deposition. This pit is nearly depleted of crushable gravel, although additional amounts have been found beneath the pit floor. These deeper gravel areas may be older esker segments that were buried by the deposition of the kame-delta. Throughout most of the pit, faces expose horizontally stratified pebbly sand with occasional pebble gravel layers.

Although Area 2a occupies a total of 210 acres (85 ha), only 100 acres (40 ha) are currently available for extraction. Most of the available area lies in the northernmost unexploited esker segment and to the south of pit 22. Assuming an average thickness of 27 feet (8 m), presently available resources of sand and gravel are estimated to be 7 million tons (6 million tonnes).

The portion of Resource Area 2 which lies to the south of Four Mile Lake consists of a sandy outwash sequence which grades southwards into a large sandy delta at the edge of the Thibeault Escarpment. The sandy outwash has been identified as Area 2b.

Area 2b forms a broad, level plain which contrasts markedly with the irregular, thinly drift-covered terrain surrounding it. Three large pits have been opened just east of the North Bay Airport. Although pits 6 and 15 are listed as active sources, only small amounts of aggregate have been removed in the recent past, and future prospects for extraction are minimal. Pits 15 and 17 form a continuous extracted area. Most faces in the pits are less than 15 feet (5 m) high and expose well sorted and stratified fine to coarse sand with some gravelly and silty layers. The eastern portion of pit 17 has been deepened considerably below the surrounding floor, and in places, more than 30 feet (9 m) of cross-stratified sand is interlayered with poorly sorted pebble and cobble gravel. Minor resources of crushable gravel may be available in the vicinity of pit 17 and below the present floor in pit 15. A ready-mix concrete plant has been built at pit 15 and aggregate is hauled in from several sources operated by Hoffman Concrete Ltd., for the production of a range of concrete products.

Pit 6 has also been opened in the upper, fine-grained portion of Area 2b. Faces in this pit range from 15 to 30 feet (5 to 9 m) and expose very well sorted and stratified fine to medium sand and silt. Although data from the Ontario Ministry of Transportation and Communications (M.T.C.) indicate that some crushable gravel was available from this portion of Area 2b, possible resources of gravel are presently minimal. The fine aggregate has been used for G.B.C. C, hot-laid asphaltic mixes, sand cushion, and fill, although silty sections are common and must be avoided.

Pit 13 is operated on a demand basis in the extreme southern part of Area 2b, below the Thibeault Escarpment. Faces in the pit are 30 feet (9 m) in height and expose well sorted and stratified fine sand and silt with a few interlayered pebbly gravel units. The material has similar use potential to that described for the upper portion of Area 2b.

Area 2b occupies a total of 1020 acres (415 ha), of which approximately 600 acres (243 ha) are presently available for extraction. Assuming an average deposit thickness of 25 feet (8 m), presently available resources of sand are estimated to be 38 million tons (34 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is the easternmost of the three esker-outwash complexes. It is the least developed of the three areas both in terms of extractive and cultural

development. It may contain large resources of sand and crushable gravel, and represents a valuable opportunity to preserve much needed resources for future developments in the North Bay area. Further investigation of the area is required to identify specific sites for extractive development. As with the other resource areas, Area 3 has been divided into several sub-areas designated by a letter suffix, on the basis of variations in thickness and gravel content.

Area 3a consists of five small esker segments, located in the northern and central portions of Resource Area 3. The esker segments are single ridges with local relief of less than 60 feet (18 m) and a maximum length of 3000 feet (910 m). The ridges are not generally accessible by road and have been delineated on the basis of air-photo interpretation. Only one pit (pit 33) has been opened in the deposits. The pit exposes less than 15 feet (5 m) of coarse sand and pebbles.

The five esker segments have a combined area of 105 acres (42 ha), of which 100 acres (40 ha) are currently available for extraction. Assuming an average thickness of 30 feet (9 m) for all units, combined resources of sand and gravel total 8 million tons (7 million tonnes).

Area 3b makes up the bulk of Resource Area 3. It forms a broad outwash plain which extends from the Little North River to the delta at the Thibeault Escarpment. The surface of the deposit is smooth to rolling. The area varies in width from less than 1000 feet (305 m) near the Little North River to a maximum of 4000 feet (1220 m) just south of pit 33. In the south, the plain has been deeply eroded by Four Mile Creek and an unnamed tributary, producing well developed terraces. Only two pits (pits 34 and 38) have been opened in Area 3b.

Pit 34 is a small, inactive pit developed in sandy outwash. The pit faces are 24 to 30 feet (8 to 9 m) high and expose moderately sorted sandy gravel. A sample of this material from pit 34 (Figure 2c) consisted of approximately 30 percent gravel, 65 percent sand, and 5 percent silt. These values are generally representative of the exposed faces in the pit. Backhoe testing was undertaken in the floor of the pit in an attempt to determine the thickness of the usable material. The test hole was dug 15 feet (5 m) below the pit floor and exposed uniform, moderately sorted, horizontally stratified pebble gravel. Sample NB-TH-8 (Figure 2a) taken from this test hole consisted of 45 percent gravel and 55 percent sand. The aggregate is of good lithologic quality and is well suited for crushing, although some selection and sand control may be required in sandy areas.

Pit 38 is a small extension of an existing road cut. The section is 20 to 25 feet (6 to 8 m) high and although extensively slumped, exposes well sorted pebbly coarse sand and some layers of pebble gravel. Oversize clasts up to 1 foot (0.3 m) in diameter were present at the base of the section. Similar coarse aggregate was observed in a stream-eroded scarp just to the west of pit 38.

Area 3b has a total of 920 acres (370 ha), of which 830 acres (335 ha) are presently available for extraction. Assuming an average thickness of 27 feet (8 m), possible sand and gravel resources are estimated to be 56 million tons (51 million tonnes). Despite the lack of subsurface data, the geomorphology of the deposit and the field observations and samples indicate that Area 3b may constitute a very important resource. Since most of the known sources of crushable gravel in the city are presently undergoing extensive extraction or have been recently depleted, further investigation, including drilling in appropriate locations, should be undertaken to confirm the quality of the material and the amount of crushable gravel.

Area 3c of Resource Area 3 constitutes the deltaic portion of the esker-outwash system. The area is separated from the rest of the deposit by the valley of Four Mile Creek. Four small pits, three of which (pits 10, 11 and 14) are presently active on a demand basis, have been opened in Area 3b. Pits 10 and 11 are developed in very well sorted and stratified sand and silt much the same as that described for the deltaic portions of Resource Areas 1 and 2. Pit 14 exposes 10 to 25 feet (3 to 8 m) of variable material ranging from cobble gravel to fine sand. Generally, resources of crushable gravel are low in Area 3c.

The area occupies a total of 390 acres (158 ha), of which 160 acres (65 ha) are currently available for extraction. Assuming an average thickness of 26 feet (8 m), presently available sand resources are estimated to be 10 million tons (9 million tonnes).

Area 3d consists of sandy outwash in the northern portion of Resource Area 3. No subsurface data exist for the northernmost

portion of the area, but airphotos indicate a relatively flat outwash plain similar, although on a smaller scale, to that described for Area 3b. A small active pit owned by the City of North Bay (pit 9) has been opened in the southern portion of Area 3d. Faces in the pit are 12 to 15 feet (4 to 5 m) high and expose well sorted fine to medium sand with occasional pebbly gravel layers. Backhoe testing was undertaken in the vicinity of this pit. Fine sand was encountered in holes NB-TH-2 and NB-TH-3 (Figure 2c) while variable amounts of sand, pebbly sand and sandy pebble gravel were encountered in test holes NB-TH-1, NB-TH-4, and NB-TH-5. Test hole NB-TH-1 (Figure 2a) was dug in the floor at Pit 9. The material exposed was predominantly clean, cross-stratified sandy pebble gravel with some interlayered sand. A sample of the material consisted of approximately 40 percent gravel and 60 percent sand. Additional coarse aggregate may be found at greater depths in the area.

Area 3d occupies a total of 470 acres (190 ha), of which 415 acres (168 ha) are presently available for extraction. Assuming an average thickness of 20 feet (6 m), possible resources of sand and minor gravel are estimated to be 21 million tons (19 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE: CITY OF NORTH BAY

Most of the deposits selected as Sand and Gravel Resource Areas of Secondary Significance either flank the existing Primary Resource Areas, or are extensions of them. The largest of these deposits is an esker-outwash system found along Selected Sand and Gravel Resource Areas 1b, c, and d. The material is composed almost entirely of sand, but small gravel pockets may be found at the northern end. The deposit grades finer to the south eventually becoming silty, fine sand. Pit 26 is the only pit found in this area and exposes coarse to fine sand. Bedrock is exposed on the pit floor.

West of Resource Area 1, near the boundary of the City of North Bay and Commanda Township is a small esker deposit. The only pit located here (pit 28) is inactive and depleted. The pit exposes well sorted sand with some poorly sorted pebble gravel. Bedrock is also found on the pit floor. Further investigation to the north may reveal additional granular resources.

South of Resource Area 1, is a small ice-contact deposit that has provided small amounts of aggregate in the past and may still be capable of production in the future. This would depend on the future development of residential and industrial complexes in the surrounding area. This deposit, however, is of relatively minor importance.

Deposits of Secondary Significance are found flanking the northern half of Resource Areas 2 and 3. No pits are located in these esker-outwash deposits, although additional quantities of sand and gravel may be available to provide resources to the North Bay area.

In the eastern part of the City of North Bay are two smaller deposits. The esker-outwash deposit in the northeast corner may contain substantial resources of coarse aggregate, but further investigation is required. The small sandy outwash deposit along Highway 63 may be able to provide material for local uses.

SELECTED SAND AND GRAVEL RESOURCE AREAS: BONFIELD, CHISHOLM, AND EAST FERRIS TOWNSHIPS

The Townships of Bonfield and Chisholm contain very large possible resources of sand and gravel in five esker and ice-contact stratified drift complexes which have been selected for possible resource protection at the primary level. Only one deposit has been selected at the primary level in East Ferris Township as aggregate resources are generally low in the area between Lake Nosbonsing and Trout Lake, and west of the Kaibuskong River. The six Selected Sand and Gravel Resource Areas occupy a total area of 3050 acres (1230 ha), of which 2900 acres (1170 ha) are currently available for extraction. The combined possible resources of sand and gravel are estimated to be 228 million tons (207 million tonnes).

Two large ice-contact stratified drift deposits in Chisholm Township, a large outwash deposit in Bonfield Township, and several smaller outwash and ice-contact stratified drift deposits scattered throughout the three townships have been selected at the secondary level. These areas may contain very large resources of sand and

minor amounts of gravel.

SELECTED SAND AND GRAVEL RESOURCE AREA 1: BONFIELD TOWNSHIP

Selected Sand and Gravel Resource Area 1 is a well developed esker-delta which trends to the southwest through the centre of Bonfield Township. The deposit forms a single sharp ridge which extends without a break from Lake Talon at the northern boundary of the township to Blueseal Creek just southeast of Bonfield, where the esker ridge spreads out into a well developed delta. The ridge has a fairly constant width of approximately 1100 feet (335 m) throughout most of its length and has consistent local relief of approximately 60 feet (18 m). In the southern portion of the deposit, the ridge is flanked and partially mantled by lower relief sandy outwash deposits, which have been selected as Sand and Gravel Resource Areas of Secondary Significance.

At least a dozen pits have been opened in the resource area and the majority are presently active at some level. The pits are not very large and have no permanent processing equipment. The pits are developed in either coarse- or fine-grained esker core deposits or in sandy flanking ice-contact stratified drift.

Faces in the coarse-grained esker core sections range from 10 to 65 feet (3 to 20 m) and expose very poorly sorted unstratified pebble to boulder gravel with abundant oversize clasts and a coarse sand matrix. This unit makes up most of the faces at pits 1 and 3, and is found in the lower portions of the faces at several other pits. A 30- to 40-foot (9 to 12 m) face at pit 1 exposes coarse sandy cross-stratified gravel which coarsens upward into the massive esker core. The core gravels are overlain by sandier, horizontally stratified gravel and sand. Samples of each of these three units were taken in pit 1 (Figure 3a) and contain approximately 20 to 67 percent gravel. A test hole (BO-TH-4; Figure 3c) was dug into the pit floor and exposed an additional 10 feet (3 m) of sandy pebble gravel containing approximately 25 percent crushable gravel.

The coarse core gravel seems to occur in nodes along the length of the esker, with the intervening portions of the ridge consisting of significantly finer-grained aggregate. Faces at pits 2, 5, and 21, for example, expose pebble gravel in 3- to 6-foot (1 to 2 m) units interlayered with cross-stratified sand and pebbly sand. The faces at pit 5 are 15 to 20 feet (5 to 6 m) high and expose moderately to well sorted, horizontally stratified pebbly medium to coarse sand, with interlayered pebble gravel. A test hole (BO-TH-10; Figure 3a) dug in the pit floor exposed 7 feet (2 m) of sandy gravel, with approximately 50 percent gravel. Several other test holes were placed in the ridge in the vicinity of pit 5 exposing 10 to 15 feet (3 to 5 m) of predominantly medium to coarse sand and pebbly sand.

Finer material is exposed in pits which are developed in the flanks of the esker. Faces at pit 12 are 10 to 12 feet (3 to 4 m) high and expose well sorted, horizontally stratified fine to coarse sand with several thick silt layers.

In summary the esker seems to consist of nodes of very coarse gravel well suited for a wide range of aggregate products, separated by intervening sandier areas where some selection and sand control would be required for crushing. Overlying and flanking this material are generally fine-grained deposits which are not suited for crushing.

The deltaic portion of the deposit consists of well sorted horizontally stratified pebbly sand with some coarser sections. A 12-foot (4 m) face at pit 6 exposes such material and a test hole dug at the base of the face exposed an additional 14 feet (4 m) of massive medium sand and planar cross-stratified pebbly sand. A sample from pit 6 (Figure 3b) consisted of approximately 20 percent gravel and 80 percent sand. A test hole (BO-TH-2; Figure 3a) was dug 600 feet (183 m) east of the pit and exposed 8 feet (2 m) of pebbly medium sand over at least 4 feet (1 m) of sandy pebble and cobble gravel. A sample of the lower unit consisted of more than 75 percent gravel. This material may represent the deposit of a main distributory channel on the delta surface. These channels may be found scattered throughout the delta, but the variability of the depositional pattern is great and selection and sand control would be required for crushing.

A 14-foot (4 m) test hole (BO-TH-1; Figure 3c) 900 feet (275 m) downslope from pit 6 exposed 10 feet (3 m) of medium sand overlying massive silt. A representative sample of material from this hole consisted of approximately 80

percent sand and 20 percent silt, thus making it unsuitable for all but the lowest specification products. Similarly, a sample taken from a small inactive pit (pit 24; Figure 3b) on the western periphery of the delta consisted of 38 percent silt and 62 percent fine sand.

The esker ridge and delta which make up Selected Resource Area 1 occupy a total of 1050 acres (425 ha), of which 975 acres (395 ha) are available for extraction. Assuming an average deposit thickness of 35 feet (11 m), presently available resources of sand and crushable gravel are estimated to be 85 million tons (77 million tonnes). There are relatively few cultural constraints on extractive development in most of the deposit. Some further investigation of the esker ridge may be required to outline the extent of the coarse gravel nodes which provide the best crushing potential. The deposit is accessible by several township roads, and at its north end is traversed by King's Highway 17. The Bonfield esker is well situated to supply demand in the aggregate-poor region of East Ferris Township.

SELECTED SAND AND GRAVEL RESOURCE AREA 2: BONFIELD TOWNSHIP

The second large sand and gravel deposit selected for resource protection at the primary level in Bonfield Township is the Rutherglen Moraine, which extends to the southwest from Rutherglen. The deposit consists of a broad irregular segmented ridge, 650 to 3300 feet (198 to 1010 m) wide and extending a distance of approximately 5 miles (8 km) from Highway 17 to the southern boundary of the township. The moraine has rolling to irregular topography and local relief of 50 to 175 feet (15 to 53 m).

Four pits (pits 7, 9, 10, and 11) have been opened in the resource area. They are small pits which are only operated intermittently. Pit 9 is an extension of a road cut in the central segment of the moraine. Faces in the pit range from 12 to 15 feet (4 to 5 m) and expose well sorted fine to medium sand and pebbly coarse sand. Oversize material, with a maximum size of 3 feet (1 m), is scattered throughout the pit. Pit 7 is now an auto junkyard, although some aggregate has been recently removed. Faces are 20 to 25 feet (6 to 8 m) high and expose 6 feet (2 m) of moderately sorted pebble and cobble gravel overlying sandy pebble gravel and sand. The average gravel content in the pit is approximately 40 percent, although this may decrease with depth. Pits 10 and 11, which are located in the southern segment of the resource area, are very small inactive sand pits. Faces are generally less than 15 feet (5 m) high and expose medium to coarse sand with rare pebbles. Much greater thicknesses of this material are probably available throughout the resource area.

No pits have been opened in the northernmost segment of the moraine and field investigation of the area showed no indication of coarse aggregate. A test hole (BO-TH-12; Figure 3c) was dug in the crest of the moraine and approximately 12 feet (4 m) of massive medium sand with a few silt seams was exposed. A sample taken of this material consisted of 87 percent sand and 13 percent silt.

Aggregate use suitability data are scarce for Resource Area 2 since very little material has been extracted. Generally, the moraine is not a crushing source, although pockets of crushable gravel, may be found in parts of the area. Fine aggregate from pit 7 has been used for hot-laid asphaltic mixes and is well suited for sand cushion and fill. Some G.B.C. A has been produced at pit 7.

Selected Sand and Gravel Resource Area 2 occupies 750 acres (305 ha), of which 730 acres (295 ha) are currently available for extraction. Assuming an average thickness of 30 feet (9 m) throughout the resource area, resources of sand are estimated to be 55 million tons (50 million tonnes). The resource area is accessible by township roads and is close to Highway 17. Although the deposit does not contain crushable gravel, it has very large resources of good-quality sand and is a significant component of the overall resource base.

SELECTED SAND AND GRAVEL RESOURCE AREA 3: CHISHOLM TOWNSHIP

Selected Sand and Gravel Resource Area 3 consists of a series of esker ridges deposited as part of the Genesee Moraine, in the southern portion of Chisholm Township. The eskers have been identified partially from field investigation but also from airphoto interpretation, because of the lack of road access in much of the area. The eskers have been selected at the primary level because of the greater probability of finding crushable gravel in them than in the

surrounding, generally fine-grained deposits of the rest of the moraine. The bulk of the moraine has been selected at the secondary level because of its low gravel content, but also because of the lack of subsurface or aggregate quality data. The area of secondary significance will be discussed in a later section.

The eskers in Resource Area 3 are all generally single, well defined ridges with local relief of 30 to 60 feet (9 to 18 m). They may be divided into two general groups: those located south of the Wistiwasing River, which have been identified almost solely on the basis of airphoto interpretation; and those segments located to the north of the river, which are more accessible and for which quantitative data are available. The general observations made on the latter group have been extended to the former group in order to make quantitative estimates.

Two pits (pits 5 and 6) have been opened in the northern group of deposits just east of Wasing. Pit 5 is an active source operated by the Township of Chisholm. Faces in the pit are up to 35 feet (11 m) high and expose 12 to 20 feet (4 to 6 m) of cross-stratified sand and pebbly sand overlying poorly sorted pebble and cobble gravel of the esker core. Aggregate from the pit is crushed for G.B.C. A and for finer-grained products. Pit 6 is a small, intermittently active source on the crest of the esker ridge just northwest of pit 5. Faces are 10 to 12 feet (3 to 4 m) high and expose poorly to moderately sorted horizontally stratified pebble to cobble gravel which consists of approximately 60 to 70 percent gravel. A test hole (CH-TH-6; Figure 4b) was dug adjacent to this pit and exposed approximately 13 feet (4 m) of horizontally to cross-stratified pebble and cobble gravel. A sample of this material consisted of 75 percent gravel, 23 percent sand, and 2 percent fines. A second hole was placed in the floor at pit 6 to determine the thickness of the coarse aggregate. The hole exposed more than 9 feet (3 m) of fine sand and interlayered silt directly below the gravel. Neither of the pits has been tested by the M.T.C. and no quantitative quality data are available. The gravel does have good lithologic quality and may be well suited for the production of a wide range of crushed products.

Several test holes were dug along a township road which intersects one of the eskers and traverses the hummocky terrain of the Genesee Moraine. Test holes CH-TH-11 and CH-TH-9 (Figure 4b) were dug in the crest and flank of the esker. Test hole CH-TH-9 exposed 3 feet (1 m) of fine sand overlying 6 feet (2 m) of clean cobble gravel. The hole was terminated because of the increasing coarseness of the clasts. A representative sample of the exposed material was taken and was found to contain approximately 65 percent gravel. Test hole CH-TH-11 exposed 6 feet (2 m) of fine sand overlying 4 feet (1 m) of coarse esker core gravel. This esker core material was sampled (CH-TH-11; Figure 4b) and found to contain nearly 60 percent gravel.

The group of esker ridges located south of the Wistiwasing River is virtually inaccessible by road and subsurface data are scarce. One test hole (CH-TH-4; Figure 4c) was dug in the floor of a small test pit in the crest of one of the western ridges. The pit has recently been opened by the Ontario Ministry of Natural Resources to identify sources for the construction of a forest access road into the Algonquin Highlands. A 12-foot (4 m) face in the pit exposes horizontally stratified sand with some pebbly layers and some gravel units. The 9-foot (3 m) test hole exposed additional medium to coarse sand and sandy gravel. A sample taken from the coarse portion of this deposit consisted of 30 percent gravel and 70 percent sand. Although information is not available for the quality or use suitability of the aggregate at this site, it is probably borderline for crushing because of the low gravel content.

The esker segments of Resource Area 3 have a combined area of 390 acres (158 ha), of which 360 acres (146 ha) are available for extraction. Assuming an average thickness of 40 feet (12 m) throughout these ridges, the total resources of sand and crushable gravel are estimated to be 36 million tons (33 million tonnes). Although data are scarce, it is likely that Resource Area 3 is a crushing source and should be able to supply most road-building and construction products. The southern group of deposits are not directly accessible by road, but are close to township roads and to a line of the Canadian National Railways. Access roads could be constructed quite easily to develop the aggregate deposits.

SELECTED SAND AND GRAVEL RESOURCE AREA 4: CHISHOLM TOWNSHIP

Selected Sand and Gravel Resource Area 4

consists of several morainic deposits and an associated esker ridge, located on the south side of Lake Nosbonsing in Chisholm Township. The morainic deposits consist of a broad segmented ridge with a width of approximately 2100 feet (640 m) and local relief of 50 to 120 feet (15 to 37 m). Two pits (pits 10 and 11) have been opened in the main ridge on either side of a township road which cuts through the deposit. Pit 11 has a 15-foot (5 m) face that exposes a thin unit of sand and silt at the top, coarsening downwards into sandy gravel, and then coarse unstratified cobble gravel. As much of the lower part of the face is obscured by slumping, gravel content cannot be confirmed. Pit 10 exposes similar coarse aggregate. Oversize clasts up to 4 feet (1.2 m) in diameter are common on the lower parts of the slumped face. The overall gravel content is probably lower than the impression given by the exposed faces. Ontario Ministry of Transportation and Communications' data indicate that selection and sand control are required for crushing. The sand in the deposit is suitable for most uses, but may grade too fine in places. The other parts of Resource Area 4 have not been extracted and no subsurface data are available. These deposits are probably also borderline crushing sources.

The total area occupied by Resource Area 4 is 435 acres (176 ha), of which 415 acres (168 ha) are currently available for extraction. Assuming an average deposit thickness of 25 feet (8 m) for the various units, presently available sand and gravel resources are estimated to be 26 million tons (24 million tonnes). The resource area is accessible by township roads and is well situated to supply local aggregate needs in the aggregate-poor portions of the project area. The resource area is surrounded by thin sandy outwash deposits which have been selected for resource protection at the secondary level.

SELECTED SAND AND GRAVEL RESOURCE AREA 5: CHISHOLM TOWNSHIP

Selected Sand and Gravel Resource Area 5 is a small esker deposit located on the Algonquin Highlands in the southern portion of the township. The resource area consists of two sinuous, well defined esker segments. The lower relief ice-contact stratified drift deposits associated with the ridges have been selected at the secondary level.

The esker ridges are approximately 2 miles (3 km) long in total and have local relief of 75 feet (23 m). Road access is poor and little subsurface information is available. The deposits have an available area of 80 acres (32 ha), and assuming an average thickness of 25 feet (8 m), have available resources of 5 million tons (4 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 6: EAST FERRIS TOWNSHIP

Selected Sand and Gravel Resource Area 6 is an isolated, morainic ice-contact stratified drift deposit, located just north of Astorville in East Ferris Township. The deposit is the only significant aggregate source in the township and is important in meeting local aggregate needs. Significant amounts of aggregate are also available from several small ice-contact stratified drift deposits located just to the south of Resource Area 6. These deposits have been selected at the secondary level.

Resource Area 6 forms a broad knoll with irregular topography and local relief of almost 150 feet (46 m). The deposit may be partially bedrock cored. Two pits (pits 1 and 19) have been opened in the deposit itself and four pits have been opened in the sandy ice-contact stratified drift deposits which mantle the lower flanks of the resource area.

Pit 1 is an active source with faces ranging from 15 to 20 feet (5 to 6 m) and exposing an upper unit of well sorted, horizontally stratified sand and silt overlying a lower unit of variable, dirty cobble gravel and sand. A sample (pit 1; Figure 5b) taken from the upper unit consisted of approximately 5 percent gravel, 82 percent sand, and 13 percent fines. A sample from the coarser lower unit (pit 1; Figure 5a) consisted of 72 percent gravel, 25 percent sand, and 3 percent fines. Several test pits have been opened to the northwest between pits 1 and 19. These pits expose the sandy material of the upper unit which is occasionally overlain by thin layers of beach gravel. Pit 19 was recently used and a 5-foot (2 m) face exposes well sorted and stratified fine to coarse sand with a few pebbly layers. A representative sample from this pit (pit 19; Figure 5b) consisted of 95 percent sand and 5 percent silt.

The only available quality data are for Pit 1. Gravel from the pit has been crushed for G.B.C. A and the sand has been used for hot-laid asphalt. The distribution of the coarse aggregate is irregular and variable. Crushable gravel is probably available only in pockets and lenses and the resource area is considered a poor crushing prospect.

Selected Resource Area 6 occupies a total of 350 acres (142 ha), of which 340 acres (138 ha) are currently available for extraction. Assuming an average deposit thickness of 25 feet (8 m), available resources of sand and minor gravel are estimated to be 21 million tons (19 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE: BONFIELD, CHISHOLM, AND EAST FERRIS TOWNSHIPS

Several large deposits and numerous smaller deposits throughout Bonfield, East Ferris, and Chisholm Townships have been selected as Sand and Gravel Resource Areas of Secondary Significance.

The largest of these deposits is the Genesee Moraine in southern Chisholm Township. The moraine forms a broad ridge 5 to 6 miles (8 to 10 km) long which extends from the eastern boundary of the township to Graham Lake. The surface of the moraine is highly irregular and has local relief in excess of 200 feet (61 m). The moraine was breached by meltwaters at Fossmill during deglaciation. The spillway is now occupied by the Wistiwasing River and divides the moraine into two segments.

There are no pits in the moraine on the south side of the river. Surface exposures on the few forest access roads in the area consist exclusively of well sorted, massive fine to medium sand. Several test holes were dug at the easternmost and westernmost margins of the deposit. The test hole at the eastern margin (CH-TH-5; Figure 4d) exposed 3 feet (1 m) of sand and interlayered silt overlying 5 feet (2 m) of massive medium sand. Two test holes south of Graham Lake exposed thin pebble beds interlayered with thick massive sand and silt. A sample taken at CH-TH-1 (Figure 4c) consisted of 5 percent gravel, 69 percent sand, and 26 percent fines. Large amounts of similar material are probably available throughout this portion of the moraine. Large resources of crushable gravel may also be available in parts of the deposit, but the dense forest cover and the lack of access severely hinders the identification of potential areas.

Road access is better in the northern portion of the moraine, and more exposures are available. This part of the deposit consists of a very rugged central ridge, surrounded by a lower-relief mantle of glaciofluvial-type sediments. Road cuts in the ridge expose predominantly sandy material, although small amounts of gravel are present. Two test holes (CH-TH-8 and CH-TH-11; Figures 4d and 4b) dug in the material flanking the esker ridges exposed till in the former and 4 feet (1.2 m) of sand over 4 feet (1.2 m) of sandy gravel in the latter. A sample from CH-TH-11 consisted of 60 percent gravel and 40 percent sand.

A small active source (pit 7, Chisholm Township) has been opened in the margin of the lower-relief, glaciofluvial material flanking the moraine. Pit faces expose moderately sorted, horizontally stratified, pebble gravel, well suited for crushing. Two samples taken from the pit ranged from approximately 35 to 65 percent gravel (Figure 4a). A test hole (CH-TH-13; Figure 4d) placed near this pit exposed fine sand consisting of approximately 5 percent gravel, 60 percent sand, and 35 percent fines. Coarse aggregate may underlie this material. Further investigation in the lower flanking deposits may identify additional amounts of crushable gravel.

The extensive outwash apron developed on the west flank of the Rutherglen Moraine has also been selected as a Secondary Sand and Gravel Resource Area. The deposit forms a broad, level, sandy plain best developed near the hamlet of Great Desert and now extensively eroded at its western margin. The plain was formed by meltwaters which flowed west from the ice margin while it stood at the Rutherglen Moraine. Although subsurface data are scarce, road cuts expose fine sand and silt. A small source (pit 26, Bonfield Township) has been opened in the deposit, but is now used as a dump. Pit faces expose 10 to 12 feet (3 to 4 m) of fine sand and silt, which has very little value as aggregate.

Thin sandy outwash flanking the Bonfield esker, and sandy deposits flanking Selected Resource Areas 4 and 5 in Chisholm Township, have been selected for possible resource protec-

tion at the secondary level. Although these deposits have not been extracted previously, they may contain small amounts of fine-grained aggregate.

Four ice-contact stratified drift deposits located in the northwestern portion of Chisholm Township have been selected as Secondary Sand and Gravel Resource Areas. The deposits contain relatively small amounts of sand and gravel, but have supported small-scale extraction in the past and are convenient local sources, especially for crushable gravel products. Four small pits have been opened in one of the deposits located in the extreme northwestern corner of Chisholm Township. Pit faces vary from 10 to 65 feet (3 to 20 m) and expose well sorted, fine to medium sand overlaying pebbly medium to coarse sand and pebble and cobble gravel. Deep faces in some of the pits expose massive, poorly sorted, cobble gravel which may be an esker core deposit. Pit 1 (Chisholm Township) is an active source developed in coarse esker-like gravels. One face is more than 45 feet (14 m) in height and exposes material containing approximately 55 percent crushable gravel. A portable crusher has been used in the pit to produce G.B.C. A for local road construction. There may be additional resources of crushable gravel left in the deposit and it is well situated to supply aggregate-poor East Ferris Township.

A second ice-contact stratified drift deposit is located just to the east, on the north shore of Wistiwasing Lake. Although no extraction has been undertaken, surface exposures along roadsides indicate sand and pebble gravel. One water well indicates 47 feet (14 m) of sand and gravel directly overlying the bedrock surface.

The third and fourth ice-contact stratified drift deposits in this area consist of broad, subdued, ridges in the vicinity of Alderdale. A pit has been opened in each of these deposits and pit faces expose medium to coarse pebble sand with thin gravelly layers.

SELECTED SAND AND GRAVEL RESOURCE AREAS: NORTH HIMSWORTH AND SOUTH HIMSWORTH TOWNSHIPS

Sand and gravel resources are not extensive in this part of the North Bay area. Five small deposits, all of which are located in South Himsworth Township have been selected for possible resource protection at the primary level. The deposits are all ice-contact stratified drift kames or eskers, except for a small outwash apron which mantles the kame at Resource Area 4.

The selected resource areas occupy a total of 2800 acres (1130 ha), of which 2450 acres (990 ha) are presently available for extraction. The combined possible sand and gravel resources are estimated to be 134 million tons (122 million tonnes). The five resource areas are the sites of most of the extraction in the two townships, and contain virtually all of the possible resources of crushable gravel.

Two large deposits, an ice-contact stratified drift deposit in North Himsworth Township and an irregular outwash plain in South Himsworth Township have been selected as Sand and Gravel Resource Areas of Secondary Significance. These areas are relatively undeveloped but may contain significant resources of sand suitable for local needs. Three small sand deposits in South Himsworth Township have also been selected as Secondary Resource Areas. Large lacustrine and outwash sand deposits cover much of the central and southern portion of South Himsworth Township, but are generally too fine grained to be of economic value.

SELECTED SAND AND GRAVEL RESOURCE AREA 1: SOUTH HIMSWORTH TOWNSHIP

Selected Sand and Gravel Resource Area 1 is a large kame located just southwest of the Town of Powassan. The deposit forms an isolated knoll with local relief in excess of 200 feet (61 m). The western portion of the deposit is covered by till, and the deposit may be partially bedrock cored. The kame is mantled on its lower slopes by an apron of outwash which has also been included in the resource area. The kame portion of the area is labelled 1a and the outwash portion 1b.

A large pit on the eastern flank of Area 1a (pit 1) is owned by Bell Construction Ltd., and is an active source. Pit faces range from 20 to 65 feet (6 to 20 m) and expose well sorted and stratified fine to coarse sand and minor silt, interlayered with poorly to moderately sorted pebble gravel. A sample (pit 1; Figure 7a) was taken from the lower coarse portion of the face and consisted of 56 percent gravel and 44 percent sand. The aggregate has been used for

G.B.C. A and B, and 16 mm crushed A, although sand control is required for crushed products. The sand and gravel are suitable for H.L. 4, although silty sections must be avoided.

Several test holes (SH-TH-1 and SH-TH-3; Figure 7b) were dug on the southwestern slope of Area 1a. The holes were 10 to 15 feet (3 to 5 m) deep and exposed predominantly horizontal to cross-stratified medium to coarse sand with only minor amounts of gravel. Larger amounts of gravel are probably present at greater depth in this locality.

Area 1a occupies a total of 200 acres (81 ha), of which 180 acres (73 ha) are presently available for extraction. Assuming an average thickness of 30 feet (9 m), presently available resources of good-quality sand and crushable gravel are estimated to be 14 million tons (13 million tonnes).

Area 1b is the sandy outwash apron which mantles the lower flanks of the kame. One source (pit 11) has been opened in Area 1b and exposes 10 to 15 feet (3 to 5 m) of medium to coarse pebbly sand. Area 1b occupies a total area of 800 acres (325 ha), of which 690 acres (280 ha) are currently available for extraction. Assuming an average deposit thickness of 15 feet (5 m), possible sand resources are estimated to be 26 million tons (24 million tonnes). Resource Area 1 has a combined possible resource tonnage of 40 million tons (36 million tonnes). The area is easily accessible by Highway 11 and is a convenient source for local aggregate.

SELECTED SAND AND GRAVEL RESOURCE AREA 2: SOUTH HIMSWORTH TOWNSHIP

Selected Sand and Gravel Resource Area 2 is an esker- ice-contact stratified drift complex in the southern portion of South Himsworth Township, just north of Trout Creek. The deposit is an irregular area of raised hummocky topography through which two esker ridges trend. As in the other resource areas, Area 2 has been subdivided based on different estimates of deposit thickness and gravel content.

Area 2a is an esker ridge, identified from airphoto interpretation. The ridge has local relief of 50 to 60 feet (15 to 18 m) and is approximately 1.5 miles (2.5 km) in length. No pits have been developed in this deposit, however, field investigation indicates crushable gravel may be present. Area 2a occupies a total of 80 acres (32 ha), of which 75 acres (30 ha) are available for extraction. Assuming an average deposit thickness of 25 feet (8 m), possible aggregate resources are estimated to be 5 million tons (4 million tonnes).

Area 2b is an ice-contact deposit which contains the largest tonnage in Resource Area 2. One source (pit 7) has been opened in the area. The pit is being operated by the Township of South Himsworth and two levels, with a total thickness of approximately 40 feet (12 m), have been excavated. The pit faces expose poorly to moderately sorted pebble gravel interlayered with abundant well sorted sand and silty fine sand. The coarse aggregate is of good quality and is suitable for a range of crushed products. Oversize clasts may pose some problems. Silty sections should be avoided in producing fine-grained aggregate.

Pit 28 is a small inactive source located in a reforested portion of Area 2b. The pit is almost completely overgrown, but approximately 10 feet (3 m) of pebbly medium to coarse sand may be seen. A test hole in the pit floor exposed an additional 3 feet (1 m) of pebbly sand overlying glacial till. The till may or may not mark the lower limit of the deposit. A sample representative of the aggregate (sample SH-TH-4; Figure 7a) consists of 35 percent gravel, 48 percent sand, and 17 percent fines. Only minor amounts of crushable gravel are present. Area 2b occupies a total of 370 acres (150 ha), of which 340 acres (138 ha) are available for extraction. Assuming an average deposit thickness of 25 feet (8 m), the presently available sand and gravel resources are estimated to be 21 million tons (19 million tonnes).

Area 2c consists of the lower relief portions of the resource area. It also includes a detached kame-like deposit at pit 8 and an esker-like linear ridge, just to the southwest. Pit 8 includes several small excavations, each of which exposes approximately 10 to 12 feet (3 to 4 m) of well sorted and stratified medium sand and pebbly coarse sand. The pits are used on a demand basis for local road-maintenance materials and for fill. Some types of hot-laid asphaltic sand may be produced. Crushing potential is low. Very little data are available for the rest of Area 2c, but it is also likely to have low crushing potential.

Several test holes were dug in the vicinity of pit 8 and in the northwest-trending ridge to the west. Test holes SH-TH-6 and SH-TH-7 were dug in the ridge and exposed approximately 13 feet (4 m) of well sorted, horizontally stratified, medium sand with occasional pebbly layers and some silty layers. A sample from test hole SH-TH-6 (Figure 7b) consisted of 93 percent medium to fine sand and 7 percent fines. Test holes SH-TH-5 and SH-TH-8 were dug in the vicinity of pit 8. The holes were 14 and 10 feet (4 and 3 m) deep, respectively, and exposed well sorted and stratified sand.

Area 2c occupies a total of 270 acres (109 ha), of which 260 acres (105 ha) are available for extraction. Assuming an average deposit thickness of 15 feet (5 m), presently available resources of sand and small amounts of gravel are estimated to be 10 million tons (9 million tonnes). Selected Resource Area 2 has a combined available area of 680 acres (275 ha) and has available resources of 36 million tons (33 million tonnes). The resource area is predominantly a sand source, although significant amounts of crushable gravel may be available in the esker ridge in the northeastern part of the deposit. Further field investigation of the ridge should be undertaken.

SELECTED SAND AND GRAVEL RESOURCE AREA 3: SOUTH HIMSWORTH TOWNSHIP

Selected Sand and Gravel Resource Area 3 is an esker complex located at the southern boundary of South Himsworth Township at Genesee Lake. Several esker ridges were identified by field observation and airphoto interpretation and they have collectively been identified as Area 3a. The remainder of the resource area has been identified as Area 3b.

The esker ridges are sharp and well defined, with average lengths of 2450 feet (750 m) and local relief up to 100 feet (30 m). Little subsurface data are available for the thickness and grain size of the aggregate in the eskers, but some small road cuts showed coarse sand and well rounded pebbles and cobbles. One small pit has been opened in the northernmost ridge in an area where the deposit has been partially mantled by younger lacustrine sand and silt. Pit 14 has been used recently and faces expose at least 20 to 25 feet (6 to 8 m) of poorly to moderately sorted pebble and cobble gravel with a coarse sand matrix. There are also interlayered units of fine gravel. The material is of good lithologic quality and is well suited for crushing. A considerable amount of G.B.C. A has been extracted for local road construction in the recent past.

Although the other ridges probably contain similar crushable gravel, further investigation should be undertaken. Resource Area 3a occupies a total of 220 acres (89 ha), of which 185 acres (75 ha) are currently available for extraction. Assuming an average deposit thickness of 40 feet (12 m), possible sand and gravel resources are estimated to be 18 million tons (16 million tonnes).

Area 3b consists of the lower-relief and irregular terrain which makes up the rest of the mapped unit. Again, very little subsurface information is available for this area, but some road cuts expose uniform medium sand. Area 3b occupies approximately 370 acres (150 ha), of which 320 acres (130 ha) are presently available for extraction. Assuming an average deposit thickness of 18 feet (6 m), possible sand resources are estimated to be 14 million tons (13 million tonnes). Selected Resource Area 3 has a combined area of 590 acres (239 ha) and a total resource tonnage of 32 million tons (29 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4: SOUTH HIMSWORTH TOWNSHIP

Selected Sand and Gravel Resource Area 4 is an isolated kame deposit which is bisected by Highway 11, just south of the Town of Powassan. The deposit forms a broad knoll with irregular but subdued relief. It is surrounded and partially mantled by fine-grained lacustrine sand and silt deposits.

Three sources (pits 6, 16, and 25) have been opened in the resource area and expose predominantly sand and silt with some gravel layers. Recently extracted faces in pit 16 are 10 to 15 feet (3 to 5 m) high and expose well sorted and stratified fine to coarse sand with common silt layers and frequent lenses and pockets of poorly sorted crushable pebble gravel. Pit 25 is a small source which may be developed in the overlying lacustrine unit. One face in the pit is 6 feet (2 m) in height and exposes silty fine to medium sand A sample from pit 25 (Figure 7b) consisted of 60 percent sand and 40 percent silt. This material has very

limited use as aggregate.

Selected Resource Area 4 occupies a total of 300 acres (121 ha), of which 245 acres (99 ha) are presently available for extraction. Assuming an average deposit thickness of 20 feet (6 m), possible resources of sand and minor gravel are estimated to be 12 million tons (11 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 5: SOUTH HIMSWORTH TOWNSHIP

Selected Sand and Gravel Resource Area 5 is an ice-contact deposit located just southeast of the Town of Trout Creek. The deposit trends for approximately 7000 feet (2130 m) in a north-south direction and its width averages 1000 feet (305 m). The resource area borders a bedrock ridge on its eastern flank.

Three pits (pits 9, 10 and 17) have been opened in this deposit. Faces in the pits expose predominantly poorly sorted granule to cobble gravel interlayered with fine to coarse sand. Silt and clay seams are present in both the sand and gravel units. Pits 9 and 10 are both active with faces ranging from 10 to 40 feet (3 to 12 m). The aggregate in pit 9 is suitable for G.B.C. B and C. In pit 10, the material is acceptable for G.B.C. A but grades too fine for hot-laid asphaltic aggregate.

Selected Sand and Gravel Resource Area 5 occupies a total of 175 acres (71 ha), of which 155 acres (63 ha) are currently available for extraction. Assuming an average thickness of 35 feet (11 m), possible sand and gravel resources are estimated to be 14 million tons (13 million tonnes). Access is provided by Highway 11 and a line of the Canadian National Railways.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE: NORTH HIMSWORTH AND SOUTH HIMSWORTH TOWNSHIPS

Two extensive deposits in North Himsworth and South Himsworth Townships have been selected as Sand and Gravel Resource Areas of Secondary Significance. Although the deposits are not crushing prospects and have not been extensively utilized in the past, they may contain significant amounts of fine aggregate suitable for local use.

The largest of the two deposits is an outwash plain situated in the valley of Genesee Creek in the southern portion of South Himsworth Township. The outwash is continuous with the esker system of Selected Resource Area 3. The surface of the deposit is rolling and has been extensively eroded by tributaries of the Genesee Creek so that some parts of the deposit may not be well suited for extraction. Three sources (pits 15, 21, and 23) have been opened in the deposit. Pit 23 exposes 12 to 20 feet (4 to 6 m) of material with sedimentary structure and grain size similar to Area 3. The lower portions of the faces expose poorly to moderately sorted and stratified pebble gravel. The coarse gravel grades upwards into, or is abruptly overlain by moderately to well sorted medium sand and silt and some pebbly sand. The coarse gravel, deposited during an earlier period of flow in the esker system, may have been buried by younger finer-grained sediments. Further investigation of the deposit may disclose additional resources of gravel.

The ice-contact stratified drift deposit selected at the secondary level in North Himsworth Township is the only significant aggregate source in that township. The deposit forms an extensive area of irregular, but subdued terrain west of Boleau Creek. Two sources (pits 1 and 2) have been opened in the deposit. Face heights in these recently used pits are generally less than 15 feet (5 m) high and expose uniform, well sorted medium sand with some fine sand and silty layers. Samples from pits 1 and 2 (Figure 6) were taken of representative faces in both pits and consisted of approximately 95 to 100 percent sand and 0 to 5 percent fines. The aggregate has been used for low-specification sand products.

Three small deposits, all located in South Himsworth Township, have also been selected as Resource Areas of Secondary Significance. The largest is an ice-contact deposit located north of the Town of Powassan. Three pits (pits 4, 22 and 24) have been opened in this deposit and faces expose coarse to silty sand. Another deposit is situated within Selected Sand and Gravel Resource Area 2 and one face exposes fine to very fine sand over bedrock. An esker deposit located northwest of Trout Creek has also been selected. No pits have been developed in this deposit, but water well records suggest the occurrence of over 60 feet (18 m) of coarse sand.

BEDROCK RESOURCES

The North Bay area lies in the northwestern part of the Grenville Province of the Precambrian Shield. The bedrock consists predominantly of highly metamorphosed metasedimentary gneisses and plutonic granitic and monzonitic rocks. There are also limited occurrences of younger intrusive rocks. The distribution of the units is shown on Maps 3A, 3B and 3C and descriptions of the units are given on the map legends (modified from Lumbers 1971). Lumbers (1971) also gives a complete description of metallic and non-metallic mineral occurrences in the project area.

The thickness of the drift covering the bedrock is generally thin and variable. Much of the land surface consists of an irregular veneer of glacial till with frequent and extensive bedrock exposures.

The oldest bedrock in the North Bay area consists of metasedimentary gneisses (Bedrock Units A, B, C, and D). These rocks were originally sandstones and siltstones which were subjected during metamorphism to high temperatures and pressures causing deformation and recrystallization into highly foliated hornblende, feldspathic and biotite gneisses. Although these units have not been quarried for aggregate in the North Bay area, they may be suitable for some crushed products (Z.L. Katona, Senior Soils and Aggregates Engineer, Ontario Ministry of Transportation and Communications, Downsview, personal communication, 1980). Biotite gneiss was quarried to the east of the project area for road-building aggregate during the construction of Highway 17 and in some areas may also be suitable for building stone (Lumbers 1971). Some of the gneisses, especially those containing large amounts of biotite, those with very well developed foliation, and those with coarse crystalline texture are susceptible to chemical and mechanical weathering, so are not well suited for load-bearing aggregate. The gneisses have not been selected for possible resource protection because the relatively abundant felsic plutonic rocks are considered more suitable for possible quarry development.

The younger felsic plutonic rocks may be divided into two types: monzonitic rocks (Bedrock Unit E); and granitic rocks (Bedrock Unit F). They are found throughout the project area and are generally thinly drift covered. Both types have undergone metamorphism and display recrystallized texture and gneissic structure. They are considered the most likely rock types in the North Bay area to be suitable for the production of road-base, hot-laid asphaltic and possibly concrete aggregate.

A quarry in Bedrock Unit F granitic rock has been opened west of the North Bay Area, near the Town of Sturgeon Falls. Analyses of the rock in this quarry were performed by the M.T.C. and indicated that the material was suitable for the production of G.B.C. A and for hot-laid asphaltic stone. Los Angeles abrasion tests, which measure the relative ability of the rock to withstand the wear and tear of traffic conditions in a road bed, give borderline results for some of the material (up to 35 percent loss by weight in standard tests). These higher than normal values are probably common for most Bedrock Units E and F rocks in the North Bay Area. The abrasion resistance standards have been modified by the M.T.C. for rock in the North Bay area and the material is considered to be acceptable for load-bearing uses.

Careful selection of the bedrock is especially important if it is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Also, some of the felsic plutonic rocks with a high feldspar and quartz content have stripping problems, in that the smooth cleavage and fracture surfaces of the minerals hinder the adhesion of asphalt and concrete mixes. This problem can be circumvented by weathering the rock for a period of time in stockpiles or by adding chemicals which erode the smooth surfaces and allow better adhesion. Several extensive areas of thinly drift-covered rocks of Bedrock Units E and F have been selected for possible resource protection in the North Bay area.

Mafic plutonic rocks (Bedrock Unit G) and alkalic complex rocks (Bedrock Unit H) are also present in the area in small scattered occurrences. These units have not been selected for possible resource protection because of their limited extent.

SELECTED BEDROCK RESOURCE AREAS: CITY OF NORTH BAY

Four areas of thinly drift-covered Unit E (monzonitic) and Unit F (granitic) bedrock have

been selected for possible resource protection in the City of North Bay. These areas occupy a total of 8600 acres (3500 ha), of which 8000 acres (3250 ha) are presently available for extractive development. Assuming an average quarriable thickness of 60 feet (18 m), the possible resources of crushed stone in the four resource areas are estimated to be 1770 million tons (1610 million tonnes).

The selection of bedrock Resource Areas 2, 3 and 4 is based on the bedrock unit's suitability for aggregate production as well as the thickness of overlying drift. Because of the small sizes of Areas 2, 3 and 4, Bedrock Resource Area 1 is considered the most viable for commercial production.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 is a very large area of Unit F bedrock overlain by 3 to 25 feet (1 to 8 m) of drift in the northeast portion of the city. The land surface in the area is irregular, but of subdued relief. Surface exposures of the bedrock are not common and much of the area is presently bush covered.

Resource Area 1 occupies a total of 6900 acres (2800 ha), of which 6500 acres (2650 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible bedrock resources are estimated to be 1440 million tons (1310 million tonnes). Although Area 1 is generally bush covered, and direct road access is limited, Highway 63 is close to its southern boundary. Access is also provided by a line of the Ontario Northland Railway which traverses the resource area along the valley of the North River.

SELECTED BEDROCK RESOURCE AREA 2

Selected Bedrock Resource Area 2 is a small area of Units E and F bedrock overlain by thin drift and located in the southern portion of the City of North Bay. The resource area occupies a total of 920 acres (370 ha), of which 820 acres (330 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 182 million tons (165 million tonnes). The resource area is accessible via Highway 11.

SELECTED BEDROCK RESOURCE AREA 3

Selected Bedrock Resource Area 3 is an area of Unit F bedrock overlain by less than 3 feet (1 m) of drift in the southeast corner of the City of North Bay. Area 3 is the western extension of an area also selected for resource protection in East Ferris Township.

Area 3 occupies a total of 325 acres (132 ha), of which 315 acres (128 ha) are presently available for extraction. Based on an average quarriable thickness of 60 feet (18 m), bedrock resources are estimated to be 70 million tons (64 million tonnes). The resource area is accessible by Highway 11 and a line of the Canadian National Railways.

SELECTED BEDROCK RESOURCE AREA 4

Selected Bedrock Resource Area 4 is a small area of Unit E bedrock overlain by 3 to 25 feet (1 to 8 m) of drift on the north shore of Trout Lake just east of Delaney Bay. The land surface is irregular and bush covered. The resource area occupies a total of 450 acres (182 ha), of which 340 acres (138 ha) are thought to be presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), the possible crushed stone resources are estimated to be 76 million tons (69 million tonnes). Parts of the resource area may not be suited for extraction because of residential and recreational developments along the lakeshore and along Highway 63.

Although Bedrock Resource Areas 2, 3 and 4 are selected for resource protection because of their rock suitability and thin drift cover, their size limits their extraction potential. Resource Area 1 has the most potential for resource development.

SELECTED BEDROCK RESOURCE AREAS: EAST FERRIS, BONFIELD AND CHISHOLM TOWNSHIPS

Four resource areas overlain by less than 25 feet (8 m) of drift have been selected for possible resource protection in these townships. The areas consist of Bedrock Units E (monzonitic) and F (granitic) bedrock and occupy a total of 19,200 acres (7800 ha). Cultural constraints reduce the area presently available to 16,900

acres (6800 ha). Assuming an average quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 3750 million tons (3400 million tonnes).

SELECTED BEDROCK RESOURCE AREA 1: EAST FERRIS TOWNSHIP

Selected Bedrock Resource Area 1 consists of several areas of Units E and F bedrock overlain by less than 3 feet (1 m) of drift in the northern portion of East Ferris Township. One of the areas extends into the City of North Bay where it has also been selected for possible resource protection. The land surface in the area is generally irregular and outcrops are common. The land has been partially cleared, although bush-covered tracts remain.

Area 1 occupies a total of 3950 acres (1600 ha), of which 3750 acres (1520 ha) are available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible bedrock resources are estimated to be 830 million tons (750 million tonnes).

Road access to most of Resource Area 1 is provided by several gravel-surfaced township roads as well as by Highways 94 and 17. Rail access is provided by a line of the Canadian Pacific Railway. Quarries could be established at numerous places throughout the northern portion of East Ferris Township.

SELECTED BEDROCK RESOURCE AREA 2: CHISHOLM TOWNSHIP

Selected Bedrock Resource Area 2 consists of four large areas of Unit E (monzonitic rock) covered by 3 to 25 feet (1 to 8 m) of drift. The areas are located south of Wistiwasing Lake and at the southern boundary of Chisholm Township. Within these areas are smaller areas of less than 3 feet (1 m) of drift. The four areas which make up Resource Area 2 occupy a total of 11,000 acres (4450 ha), of which 9200 acres (3700 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 2050 million tons (1860 million tonnes).

Portions of the area at Wistiwasing Lake are extensively cleared and are under cultivation. The southern parts of the area are extensively bush covered. Road access is provided by a well developed grid of township roads in the north, but in the south, road access is limited. A line of the Canadian Pacific Railway crosses the southern end of the resource area at Wistiwasing Lake.

SELECTED BEDROCK RESOURCE AREA 3: BONFIELD TOWNSHIP

Selected Bedrock Resource Area 3 consists of several relatively small areas of Unit E bedrock overlain by less than 3 feet (1 m) of drift. The area is situated in the central portion of Bonfield Township.

Resource Area 3 occupies a total of 2600 acres (1050 ha), of which 2400 acres (970 ha) are presently available for extraction. Based on a quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 530 million tons (480 million tonnes). Road access is good and quarries might be established in a number of locations.

SELECTED BEDROCK RESOURCE AREA 4: CHISHOLM TOWNSHIP

In Selected Bedrock Resource Area 4, 3 to 25 feet (1 to 8 m) of drift overlies Unit F (granitic rocks). The resource area is located along the western boundary of Chisholm Township and extends into South Himsworth Township where it has also been selected for possible resource protection. The area occupies a total of 1600 acres (650 ha), of which 1570 acres (640 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible bedrock resources are estimated to be 350 million tons (320 million tonnes). The area has limited road access and is heavily bush covered.

SELECTED BEDROCK RESOURCE AREAS: NORTH HIMSWORTH AND SOUTH HIMSWORTH TOWNSHIPS

Most of the areas of thinly drift-covered Bedrock Units E and F have been selected for resource protection in North and South Himsworth Townships. Selected Area 1 is situated in the western portion of North Himsworth Township and consists of predominantly Bedrock Unit F. The area is overlain by 3 to 25 feet (1 to 8 m) of drift but bedrock exposures are common. Selected Resource Areas 2 and 3 are irregular areas of Bedrock Units E and F overlain by 3 to 25 feet (1 to 8 m) of drift

in the southeastern portion of South Himsworth Township.

The three resource areas occupy a total of 13,100 acres (5300 ha), of which 12,300 acres (5000 ha) are presently available for extraction. Based on an average quarriable thickness of 60 feet (18 m), the total crushed stone resources in the selected areas in both townships are estimated to be 2700 million tons (2450 million tonnes).

SELECTED BEDROCK RESOURCE AREA 1: NORTH HIMSWORTH AND SOUTH HIMSWORTH TOWNSHIPS

Selected Bedrock Resource Area 1 is an irregular and extensive area overlain by thin drift and containing bedrock exposures. The area is located along the western boundary of North Himsworth Township and the northwest corner of South Himsworth Township and is underlain predominantly by Bedrock Unit F, except for a few small linear bodies of Unit E rock extending to the southeast from the southern shore of Lake Nipissing.

Resource Area 1 occupies a total of 5800 acres (2350 ha), of which 5200 acres (2100 ha) are presently available for extraction. Assuming an average quarriable thickness of 60 feet (18 m), possible crushed stone resources in Area 1 are estimated to be 1160 million tons (1050 million tonnes). Much of the land surface, especially in the northern portion of the area, has been cleared, but is not intensively cultivated. Road access is provided by gravel-surfaced township roads, which are better developed in the northern portion of the deposit. Highway 654 traverses the northern portion of the resource area.

SELECTED BEDROCK RESOURCE AREA 2: SOUTH HIMSWORTH TOWNSHIP

A large area of Bedrock Units E and F overlain by up to 25 feet (8 m) of drift has been selected for possible resource protection in the south-central portion of South Himsworth Township. The resource area is bounded by areas of thicker drift in the valleys of McGillvray and Genesee Creeks. Most of the bedrock in the resource area consists of monzonitic Unit E rocks except for smaller areas of granitic Unit F rocks in the southern end of the resource area. The southern boundary of the resource area is marked by the southern limit of the only bedrock map available for the region (Lumbers 1971). Further resources of suitable bedrock may be available in areas of thin drift east of the Town of Trout Creek, although no attempt has been made to delineate such areas on Map 3. Further field mapping of the bedrock is required.

The land surface in Area 2 is smooth to irregular and bedrock exposures are not common except for a large bedrock knob located just east of the Town of Powassan. Resource Area 2 occupies a total of 7000 acres (2850 ha), of which 6800 acres (2750 ha) are presently available for extraction. Assuming an average quarriable thickness of 60 feet (18 m), possible bedrock resources are estimated to be 1500 million tons (1360 million tonnes).

A large proportion of the land in Area 2 has been cleared for agriculture and has been used for pasture and cultivation. However, large amounts of bush-covered land still remain. Although road access is not well developed, Highway 11 and a line of the Canadian National Railways are located at the western boundary of the resource area and would provide convenient haul routes for a large-scale operation.

SELECTED BEDROCK RESOURCE AREA 3: SOUTH HIMSWORTH TOWNSHIP

Selected Bedrock Resource Area 3 is an area of Bedrock Unit F (granitic rocks) covered by 3 to 25 feet (1 to 8 m) of drift on the east side of Genesee Creek at the eastern boundary of South Himsworth Township. The resource area occupies a total of 1260 acres (510 ha), of which 1160 acres (470 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 260 million tons (236 million tonnes). The area is heavily bush covered and road access is limited.

SUMMARY

The North Bay area has possible resources of good-quality sand and gravel suited for a wide range of road-building and construction aggregate. Several deposits have been selected for possible resource protection at the primary level and these areas contain virtually all of the resources of crushable gravel in the North Bay area. Although large gravel resources remain,

they are presently being extracted at a rapid pace. Care should be taken to ensure the continuing availability of as much of the gravel resources as possible. Large resources of sand are available throughout the North Bay area and several large deposits have been selected as Sand and Gravel Resource Areas of Secondary Significance.

Most of the North Bay area is underlain by Precambrian metasedimentary, granitic, and monzonitic rocks. The latter two bedrock types are considered the most suitable for possible quarry development. Several areas covered by thin drift have been selected for possible resource protection. These areas may become important in the future when resources of crushable gravel become scarce.

Enquiries regarding the Aggregate Resources Inventory of the North Bay area should be directed to the Ontario Ministry of Natural Resources, either at the North Bay District Office, 222 McIntyre Street West, North Bay, Ontario, P1B 8K7 (Tel. (705) 474-5550) or at the Northeastern Region Office, 199 Larch Street, Sudbury, Ontario, P3E 5P9 (Tel. (705) 675-4120).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, NORTH BAY AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
CITY OF NORTH BAY			
1	G-E	390 (158)	30 (27)
	G-E-OW	2300 (930)	145 (132)
	S-E-OW	1690 (680)	115 (104)
	S-IC	320 (130)	30 (27)
	S-LB	220 (89)	11 (10)
	S-OW	750 (305)	40 (36)
2	S-E-OW	2900 (1170)	90 (82)
	S-OW	111 (45)	3 (3)
3	S-E-OW	860 (350)	15 (14)
	S-IC	630 (255)	10 (9)
	S-OW	45 (18)	1 (1)
4	S-LP	167 (68)	2 (2)
		10,400 (4200)	490 (445)
BONFIELD TOWNSHIP			
1	G-E	1040 (420)	90 (82)
	S-IC	920 (370)	90 (82)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, NORTH BAY AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
2	S-IC	130 (53)	5 (4)
	S-OW	5300 (2140)	200 (181)
3	S-LP	4200 (1700)	85 (77)
	S-OW	2200 (890)	45 (41)
4	S-LP	450 (182)	5 (4)
	S-OW	145 (59)	2 (2)
		14,400 (5800)	520 (470)
CHISHOLM TOWNSHIP			
1	G-E	510 (206)	30 (27)
	G-IC	150 (61)	10 (9)
	S-E-IC	390 (158)	30 (27)
	S-IC	7000 (2850)	525 (475)
	S-OW	50 (20)	3 (3)
2	S-LP	730 (295)	25 (23)
	S-OW	3850 (1560)	145 (132)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, NORTH BAY AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
3	S-IC	15 (6)	<1 (<1)
	S-LP	5800 (2350)	115 (104)
	S-OW	1840 (740)	35 (32)
4	S-OW	240 (97)	2 (2)
		20,300 (8300)	920 (835)
EAST FERRIS TOWNSHIP			
1	S-IC	830 (335)	50 (45)
2	S-IC	570 (231)	20 (18)
	S-LP	560 (227)	20 (18)
3	S-LP	2950 (1190)	60 (54)
	S-OW	145 (59)	3 (3)
4	S-LP	20 (8)	<1 (<1)
		5100 (2060)	153 (139)
NORTH HiMSWORTH TOWNSHIP			
1	S-IC	220 (89)	15 (14)
2	S-AL	85 (34)	3 (3)
	S-IC	690 (280)	25 (23)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, NORTH BAY AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
3	S-IC	16 (6)	<1 (<1)
	S-LP	1480 (600)	30 (27)
4	S-LP	210 (85)	2 (2)
		2700 (1090)	75 (68)
SOUTH HIMSWORTH TOWNSHIP			
1	G-E	230 (93)	20 (18)
	G-IC	420 (170)	30 (27)
	S-AL	1075 (435)	55 (50)
	S-E	40 (16)	3 (3)
	S-IC	1000 (405)	60 (54)
2	S-AL	230 (93)	10 (9)
	S-IC	1160 (470)	45 (41)
	S-LP	3050 (1230)	115 (104)
	S-OW	7000 (2840)	260 (236)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, NORTH BAY AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
3	S-IC	55 (22)	1 (1)
	S-LP	5400 (2180)	110 (100)
	S-OW	1040 (420)	20 (18)
4	S-IC	64 (26)	1 (1)
	S-LP	60 (24)	1 (1)
	S-OW	12 (5)	<1 (<1)
		20,800 (8400)	730 (660)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
CITY OF NORTH BAY						
1	N5-153	Standard Paving	23	5	20 (6)	60-80
2	N5-146	Greco Paving	22	5	20-30 (6-9)	20-80 (variable)
3	N5-139	Delorme	22	5	15-25 (5-8)	60-80
4	N5-28	Northfield Block & Gravel Ltd.	19	3	65 (20)	10
5	N5-35	Terault Construction Ltd.	20	2	12-20 (4-6)	0-60 (variable)
6	N5-103	Robert Landscaping Ltd.	14	A	15-30 (5-9)	–
7	N5-36	Henry's Excavating	20	1	15-30 (5-9)	0-5
8	N5-52	J.R. Norbie	14	3	12 (4)	70-80
9	N5-145	City of North Bay	10	5	12-15 (4-5)	0-10
10	N5-121	Fownes	7	A	10-30 (3-9)	0-70 (variable)
11	–	Sale	7, 8	A	30-65 (9-20)	sand
12	–	Devillers	20	4	30 (9)	60-70
13	N5-110	Widdified	12, 13	B	30 (9)	0-10
14	–	Luxton	7	A	10-25 (3-8)	sand (variable)
15	N5-101 N5-113	Hoffman Concrete Ltd.	14	1	12 (4)	sand

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
16	N5-18	Unknown	5	2	50 (15)	70
17	N5-111	N. Keller	13	1	35 (11)	20-40
18	N5-131 N5-132 N5-119	Delorme (Bomarc Pit)	23	5,6	20 (6)	50-70
19	N5-27 N5-37 N5-85	MTC Henry's Excav. Acme Sand and Gravel	21	4	50 (15)	variable
20	N5-22	A. Gautner	19	4	–	–
21	N5-104	Hoffman Concrete Ltd.	14	3	25 (8)	80
22	N5-83	Hoffman Concrete Ltd.	14	3	–	–
23	N5-84 N5-86	D. Hotte L.J. Brouse Construction Ltd.	20	3	30-80 (9–24)	–
24	N5-147	L.J. Brouse Construction Ltd.	20	2	25 (8)	10-20
25	N5-14	Standard Paving Ltd.	19	2	20-65 (6-20)	–
26	N5-55	Sterling Construction Ltd.	19	1	–	–
27	N5-149	Delorme	20	1	12 (4)	sand
28	N5-17	Delorme	23, 24	1, A	5-10 (2-3)	sand
29	–	Unknown	18	2	–	–
30	N5-112	Ministry of Natural Resources	10	B	–	–

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
31	N5-106	P. Devillers	19	4	20 (6)	30-40
32	N5-140	J.M. Wright and Son Ltd.	19	4	20-25 (6-8)	–
33	N5-114	Standard Paving Ltd.	10	2, 3	15 (5)	–
34	N5-107	City Sand and Gravel Ltd.	9	2	25-30 (8-9)	40
35	N5-102	C.A. DuFresne	13, 14	2	12-15 (4-5)	20-40
36	N5-127	Northern Brick and Tile Ltd.	22	5	15-20 (5-6)	30
37	N5-54	E. Bailey	14	4	12 (4)	–
38	N5-108	Unknown	9	A	20-25 (6-8)	10-30
39	N5-2	Robinson	7	1	10-12 (3-4)	20-30
40	N5-1	Tyres	2	2	15-20 (5-6)	30-40
41	–	Unknown	9	B	30-50 (9-15)	50
42	–	Unknown	20	B	30-40 (9-12)	45
43	N5-16	Delorme	19	A, B	40-45 (12-14)	sand
44	N5-50	Charron	29	15	15 (5)	–
45	N5-44	Unknown	30	17	3-5 (1-2)	–

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
46	N5-118	Unknown	9	B	–	–
47	–	Unknown	38	11	12 (4)	–
BONFIELD TOWNSHIP						
1	P21-70	Benoit	16	7	30-40 (9-12)	70-80
2	P21-70	Benoit	16	7	12 (4)	sand
3	N5-96	H. Scott	23	11	10-65 (3-20)	0-70 (variable)
4	N5-59	MTC	23, 24	11	65-70 (20-21)	45
5	P21-72	Benoit	17	8	15-20 (5-6)	30-60
6	P21-85	R. Amyott	12	5	12 (4)	0-5
7	P21-79	Laplante	33	4	20-25 (6-8)	30-40
8	N5-92	Boissoneault	2, 3	13	10-20 (3-6)	5-60 (variable)
9	P21-78	Bellaire	34	4, 5	12-15 (4-5)	5-20
10	–	Unknown	30, 31	1	12-15 (4-5)	0-10
11	–	Unknown	30, 31	1	5-10 (2-3)	sand
12	P21-73	Bedard	15	7	10-12 (3-4)	sand
13	N5-61	Graham	21	9	30 (9)	20-30

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
14	N5-62	McNutty	20	9	40-50 (12-15)	10-20
15	N5-100	Geddes	33	7	15 (5)	sand
16	–	Boisvert	9	8	40-50 (12-15)	–
17	–	Unknown	32	11	–	–
18	–	B. Maclaren	34	11	12-15 (4-5)	0-10
19	–	Unknown	27	12, 13	10-15 (3-5)	0-60 (variable)
20	–	Unknown	29	11	10 (3)	–
21	N5-97 N5-64	Brown Rose	22, 23	10	10-30 (3-9)	5
22	N5-68	Boissongault	3	13	10-12 (3-4)	–
23	N5-58	N. Toner	2	13	5-10 (2-3)	–
24	–	Unknown	10	6	3-5 (1-2)	–
25	–	Joe Swift	9	8	5 (2)	75
26	–	Unknown	30	5	10-12 (3-4)	–
27	P21-91	Armstrong	20	6	5-10 (2-3)	20
28	P21-60	Unknown	11	9	3-5 (1-2)	70
29	–	Unknown	10	3	–	70

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
30	P21-69	Unknown	10	3	–	–
31	–	Unknown	9	8	3-10 (1-3)	70
CHISHOLM TOWNSHIP						
1	–	Sauage # 1	2	18	25-50 (8-15)	55
2	–	Sauage # 2	1	17	50-65 (15-20)	20-30
3	P21-63	Sauage # 3	1	17	12-20 (4-6)	–
4	P21-60	Sauage # 4	1	17	10-15 (3-5)	–
5	–	Chisholm Township	23	6	3-35 (1-11)	–
6	–	Chisholm Township	22, 23	6	10-12 (3-4)	60-70
7	P21-88	Buckley	26	9	25-30 (8-9)	40-60
8	–	Unknown	7	13	25-35 (8-11)	–
9	–	Buckley	6	9	12-15 (4-5)	–
10	P21-68	P. Bessette	24, 25	17	30-50 (9-15)	35-45
11	P21-67	Larochelle	24, 25	16	30-50 (9-15)	30
12	–	Unknown	10, 11	18	5-10 (2-3)	–
13	–	Unknown	6	9	10 (3)	20
14	–	Unknown	20	5	12 (4)	–

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
EAST FERRIS TOWNSHIP						
1	P21-94	Perron	20	4	15-20 (5-6)	20
2	P21-100	Unknown	25	3	20 (6)	–
3	P21-66	P. Gauthier	16	5	20-25 (6-8)	20-25
4	–	Saragans	3	6	6-10 (2-3)	–
5	–	Unknown	14	4	–	–
6	–	Unknown	20	4	12 (4)	sand
7	P21-06	Rochefort	16, 17	4	6-10 (2-3)	20
8	–	Paulette	3	7	10-15 (3-5)	–
9	P21-64	S. Noowell	29	10	6-15 (2-5)	sand
10	N5-128	Mrs. G. West	16, 17	11	10-12 (3-4)	15
11	–	Reg Gravelle	17	10	3-8 (1-2)	-
12	P21-11	Gauthier	19	4	10-12 (3-4)	–
13	P21-59	CNR	28	8	10-15 (3-5)	sand
14	P21-99	Nosbonsing Park Ltd.	4	4	25-35 (8-11)	–
15	P21-33	Beleque	18	4	25 (8)	15

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
16	–	Unknown	16	3	35-50 (11-15)	–
17	–	Aurel Perron	19	2	–	–
18	–	Astorville Cemetery	19	2	6-10 (2-3)	–
19	–	Perron	19	4	5 (2)	–
20	–	Unknown	25	2	6 (2)	–
21	–	Leo Taillgfer	10	10	25-30 (8-9)	–
22	–	C. Champogne	20	8	6-10 (2-3)	–
23	N5-34	J. Gravelle	17, 18	10	6-10 (2-3)	–
24	P21-02	Foxwell	24	8	4-8 (1-2)	–
25	–	East Ferris	19, 20	6, 7	–	–
26	–	Unknown	10	9	–	–
SOUTH HIMSWORTH TOWNSHIP						
1	P21-17	Bell Construction Ltd.	17, 18	11, 12	20-65 (6-20)	10-40
2	P21-32	Jardine	16	14	10-12 (3-4)	sand
3	–	Williams	15	17	10-12 (3-4)	0-10
4	P21-14	(MTC) Smith	15	14	25-30 (8-9)	sand
5	–	Clayton Cambell	11	13	10-15 (3-5)	–

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
6	P21-21	Yonge-Phillips	16, 17	9	20-30 (6-9)	5-60
7	–	South Himsworth Township	24	7	10-40 (3-12)	60-70
8	P21-80	Rick's Pit	23, 24	5	10-12 (3-4)	0-20
9	S30-6	G. Hummel	24	2	10-40 (3-12)	0-65
10	S30-13	Ciglen	25	1	30-40 (9-12)	40
11	–	Warrener	16	11	10-15 (3-5)	–
12	–	Ken Rich	10, 11	11	20-25 (6-8)	sand
13	–	Unknown	21	15	12-20 (4-6)	sand
14	–	Herman Keown	5	5	20-25 (6-8)	70
15	–	J. Lawrence	6	8	20-25 (6-8)	60
16	P21-19	Luxton	15	9	10-35 (3-11)	20-40
17	S30-38	Ciglen # 2	25	1	10-35 (3-11)	20-40
18	P21-82	McCorkell	19, 20	15	35 (11)	–
19	P21-57	E. Robinson	3, 4	11	6 (2)	–
20	P21-42	E. Cowan	1	10	–	–
21	P21-41	Feher	1	8	overgrown	–

TABLE 2 | SAND AND GRAVEL PITS, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL
22	P21-13	Wilson	14	15	20-25 (6-8)	–
23	–	Osbornison	4	6	12-20 (4-6)	–
24	P21-30	Brownlee	15	15	10-12 (3-4)	–
25	P21-81	Gene Young's Pit	16	9	10-12 (3-4)	–
26	P21-83	Phillips	17	9	–	–
27	P21-28	Bartraw	20	9	10-25 (3-8)	–
28	P21-10	Dunna Holdings Ltd.	25	6	6-10 (2-3)	0-10
29	S30-61	T. McGrath	35, 36	2	10-12 (3-4)	–
30	P21-15	Hanson	3	13	–	–
NORTH HIMSWORTH TOWNSHIP						
1	P21-37	Beyers	23	22	8-10 (2-3)	sand
2	P21-34	Unknown	20	24	12-15 (4-5)	sand
3	P21-35	Daniher	12	22	8-10 (2-3)	sand
4	P21-38	Warbrick	2	24	3-12 (1-4)	–
5	P21-1	Ricker	1	24	3-40 (1-12)	–
6	P21-96	Unknown	7	20	–	–
7	P21-29	Sauage	8	18	–	–

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
CITY OF NORTH BAY						
1a	340 (138)	20 (8)	190 (77)	130 (53)	25 (8)	8 (7)
1b	150 (61)	5 (2)	110 (44)	35 (14)	45 (14)	4 (4)
1c	1120 (455)	450 (182)	70 (28)	600 (243)	23 (7)	34 (31)
1d	600 (243)	100 (40)	175 (71)	325 (132)	35 (11)	28 (25)
1e	690 (280)	10 (4)	0 (0)	680 (275)	15 (5)	26 (24)
	2900 (1170)	580 (235)	540 (218)	1770 (720)		100 (91)
2a	210 (85)	0 (0)	110 (44)	100 (44)	27 (8)	7 (6)
2b	1020 (415)	220 (89)	200 (81)	600 (243)	25 (8)	38 (34)
	1230 (500)	220 (89)	310 (126)	700 (285)		45 (41)
3a	105 (42)	0 (0)	5 (2)	100 (40)	30 (9)	8 (7)
3b	920 (370)	80 (32)	10 (4)	830 (335)	27 (8)	56 (51)
3c	390 (158)	200 (81)	30 (12)	160 (65)	26 (8)	10 (9)
3d	470 (190)	50 (20)	5 (2)	415 (168)	20 (6)	21 (19)
	1880 (760)	330 (134)	50 (20)	1500 (610)		95 (86)
	6000 (2430)	1130 (455)	900 (365)	3950 (1600)		240 (218)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
BONFIELD TOWNSHIP						
1	1050 (425)	50 (20)	25 (10)	975 (395)	35 (11)	85 (77)
2	750 (305)	10 (4)	10 (4)	730 (295)	30 (9)	55 (50)
	1800 (730)	60 (24)	35 (14)	1700 (690)		140 (127)
CHISHOLM TOWNSHIP						
3	390 (158)	15 (6)	15 (6)	360 (146)	40 (12)	36 (33)
4	435 (176)	0 (0)	20 (8)	415 (168)	25 (8)	26 (24)
5	85 (34)	0 (0)	5 (2)	80 (32)	25 (8)	5 (4)
	900 (365)	15 (6)	40 (16)	860 (350)		67 (61)
EAST FERRIS TOWNSHIP						
6	350 (142)	10 (4)	0 (0)	340 (138)	25 (8)	21 (19)
	3050 (1230)	85 (34)	75 (30)	2900 (1170)		228 (207)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
SOUTH HIMSWORTH TOWNSHIP						
1a	200 (81)	5 (2)	15 (6)	180 (73)	30 (9)	14 (13)
1b	800 (325)	110 (44)	0 (0)	690 (280)	15 (5)	26 (24)
	1000 (405)	115 (46)	15 (6)	870 (350)		40 (36)
2a	80 (32)	5 (2)	0 (0)	75 (30)	25 (8)	5 (4)
2b	370 (150)	25 (10)	5 (2)	340 (138)	25 (8)	21 (19)
2c	270 (105)	5 (2)	5 (2)	260 (105)	15 (5)	10 (9)
	720 (290)	35 (14)	10 (4)	680 (275)		36 (33)
3a	220 (89)	30 (12)	5 (2)	185 (75)	40 (12)	18 (16)
3b	370 (150)	50 (20)	0 (0)	320 (130)	18 (6)	14 (13)
	590 (239)	80 (32)	5 (2)	500 (202)		32 (29)
4	300 (121)	40 (16)	15 (6)	245 (99)	20 (6)	12 (11)
5	175 (71)	7 (3)	13 (5)	155 (63)	35 (11)	14 (13)
	2800 (1130)	275 (111)	58 (23)	2450 (990)		134 (122)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
CITY OF NORTH BAY				
0-3 (0-1)	Type A	60 (18)	8600 (3500)	1910 (1730)
3-25 (1-8)	Type A	60 (18)	16,400 (6600)	3650 (3300)
			25,000 (10 100)	5600 (5100)
0-3 (0-1)	Type B	60 (18)	485 (196)	108 (98)
3-25 (1-8)	Type B	60 (18)	22,300 (9000)	4950 (4500)
			22,800 (9200)	5100 (4650)
0-3 (0-1)	Type D	60 (18)	128 (52)	28 (25)
3-25 (1-8)	Type D	60 (18)	131 (53)	29 (26)
			260 (105)	57 (52)
3-25 (1-8)	Type E	60 (18)	450 (182)	100 (91)
0-3 (0-1)	Type F	60 (18)	420 (170)	93 (84)
3-25 (1-8)	Type F	60 (18)	9200 (3700)	2030 (1840)
			9600 (3900)	2120 (1920)
			58,000 (23 500)	13,000 (11 800)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
BONFIELD TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	7200 (2900)	1600 (1450)
3-25 (1-8)	Type A	60 (18)	5100 (2060)	1130 (1020)
			12,300 (5000)	2750 (2500)
0-3 (0-1)	Type D	60 (18)	50 (20)	11 (10)
3-25 (1-8)	Type D	60 (18)	145 (59)	32 (29)
			195 (79)	43 (39)
0-3 (0-1)	Type E	60 (18)	2500 (1010)	560 (510)
3-25 (1-8)	Type E	60 (18)	22,300 (9000)	4950 (4500)
			24,800 (10 000)	5500 (5000)
0-3 (0-1)	Type F	60 (18)	215 (87)	48 (44)
3-25 (1-8)	Type F	60 (18)	40 (16)	9 (8)
			255 (103)	57 (52)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
0-3 (0-1)	Type G	60 (18)	135 (75)	41 (37)
3-25 (1-8)	Type G	60 (18)	40 (16)	9 (8)
			75 (71)	50 (45)
			37,700 (15 200)	8400 (7600)
CHISHOLM TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	900 (365)	200 (181)
3-25 (1-8)	Type A	60 (18)	12,000 (4850)	2650 (2400)
			12,900 (5200)	2850 (2600)
3-25 (1-8)	Type B	60 (18)	15 (6)	3 (3)
3-25 (1-8)	Type C	60 (18)	40 (16)	9 (8)
0-3 (0-1)	Type E	60 (18)	1900 (770)	420 (380)
3-25 (1-8)	Type E	60 (18)	9900 (4000)	2200 (2000)
			11,800 (4800)	2600 (2360)
0-3 (0-1)	Type F	60 (18)	70 (28)	16 (14)
3-25 (1-8)	Type F	60 (18)	2090 (850)	465 (420)
			2160 (870)	480 (435)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
0-3 (0-1)	Type G	60 (18)	5 (2)	1 (1)
3-25 (1-8)	Type G	60 (18)	70 (28)	16 (14)
			75 (30)	17 (15)
			27,000 (10 900)	6000 (5400)
EAST FERRIS TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	7200 (2900)	1600 (1450)
3-25 (1-8)	Type A	60 (18)	9000 (3650)	2000 (1810)
			16,200 (6600)	3600 (3250)
0-3 (0-1)	Type D	60 (18)	345 (140)	76 (69)
3-25 (1-8)	Type D	60 (18)	405 (164)	90 (82)
			750 (305)	166 (150)
0-3 (0-1)	Type E	60 (18)	1150 (465)	255 (231)
3-25 (1-8)	Type E	60 (18)	7300 (2950)	1620 (1470)
			8400 (3400)	1880 (1710)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
0-3 (0-1)	Type F	60 (18)	3290 (1330)	730 (660)
3-25 (1-8)	Type F	60 (18)	4150 (1680)	920 (840)
			7400 (3000)	1650 (1500)
0-3 (0-1)	Type G	60 (18)	50 (20)	11 (10)
3-25 (1-8)	Type G	60 (18)	25 (10)	6 (5)
			75 (30)	17 (15)
			33,000 (13 400)	7300 (6600)
NORTH HIMSWORTH TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	1460 (590)	325 (295)
3-25 (1-8)	Type A	60 (18)	1870 (760)	415 (375)
			3350 (1360)	740 (670)
0-3 (0-1)	Type E	60 (18)	510 (206)	113 (102)
3-25 (1-8)	Type E	60 (18)	8300 (3350)	1840 (1670)
			8800 (3550)	1950 (1770)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, NORTH BAY AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK* LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
0-3 (0-1)	Type F	60 (18)	4300 (1740)	950 (860)
3-25 (1-8)	Type F	60 (18)	6400 (2600)	1420 (1290)
			10,700 (4350)	2370 (2150)
0-3 (0-1)	Type H	60 (18)	270 (109)	60 (54)
3-25 (1-8)	Type H	60 (18)	325 (132)	72 (65)
			600 (243)	132 (120)
			23,400 (9500)	5200 (4700)
SOUTH HIMSWORTH TOWNSHIP				
3-25 (1-8)	Type A	60 (18)	1960 (790)	435 (395)
0-3 (0-1)	Type E	60 (18)	870 (350)	193 (175)
3-25 (1-8)	Type E	60 (18)	11,600 (4700)	2600 (2360)
			12,500 (5100)	2800 (2550)
0-3 (0-1)	Type F	60 (18)	1190 (480)	265 (240)
3-25 (1-8)	Type F	60 (18)	6700 (2700)	1490 (1350)
			7900 (3200)	1760 (1600)
			22,400 (9100)	5000 (4550)

* For a description of the different rock types, see Appendix D.

TABLE 5 | QUARRIES, NORTH BAY AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 QUARRY STATUS

– NONE –

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
CITY OF NORTH BAY							
1	3-25 (1-8)	6900 (2800)	400 (162)	0 (0)	6500 (2650)	60 (18)	1440 (1310)
2	3-25 (1-8)	920 (370)	100 (40)	0 (0)	820 (330)	60 (18)	182 (165)
3	0-3 (0-1)	325 (132)	10 (4)	0 (0)	315 (128)	60 (18)	70 (64)
4	3-25 (1-8)	450 (182)	110 (44)	0 (0)	340 (138)	60 (18)	76 (69)
Total Map 3A		8600 (3500)	620 (250)	0 (0)	8000 (3250)		1770 (1610)
BONFIELD TOWNSHIP							
3	0-3 (0-1)	2600 (1050)	200 (81)	0 (0)	2400 (970)	60 (18)	530 (480)
CHISHOLM TOWNSHIP							
2	0-3 (0-1)	1690 (680)	150 (61)	0 (0)	1540 (620)	60 (18)	340 (310)
	3-25 (1-8)	9300 (3750)	1600 (650)	0 (0)	7700 (3100)	60 (18)	1710 (1550)
		11,000 (4450)	1750 (710)	0 (0)	9200 (3700)		2050 (1860)

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
4	3-25 (1-8)	1600 (650)	30 (12)	0 (0)	1570 (640)	60 (18)	350 (320)
EAST FERRIS TOWNSHIP							
1	0-3 (0-1)	3950 (1600)	200 (81)	0 (0)	3750 (1520)	60 (18)	830 (750)
Total Map 3B		19,200 (7800)	2180 (880)	0 (0)	16,900 (6800)		3750 (3400)
NORTH HIMSWORTH TOWNSHIP							
1	0-3 (0-1)	4800 (1940)	500 (202)	0 (0)	4300 (1740)	60 (18)	960 (870)
SOUTH HIMSWORTH TOWNSHIP							
1	0-3 (0-1)	960 (390)	80 (32)	0 (0)	880 (355)	60 (18)	195 (177)
2	0-3 (0-1)	205 (83)	10 (4)	0 (0)	195 (79)	60 (18)	43 (39)
	3-25 (1-8)	5800 (2350)	100 (40)	0 (0)	5700 (2310)	60 (18)	1260 (1140)
		6000 (2430)	110 (44)	0 (0)	5900 (2390)		1300 (1180)

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, NORTH BAY AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
3	3-25 (1-8)	1260 (510)	100 (40)	0 (0)	1160 (470)	60 (18)	260 (236)
Total Map 3C		13,000 (5300)	790 (320)	0 (0)	12,200 (4950)		2700 (2450)

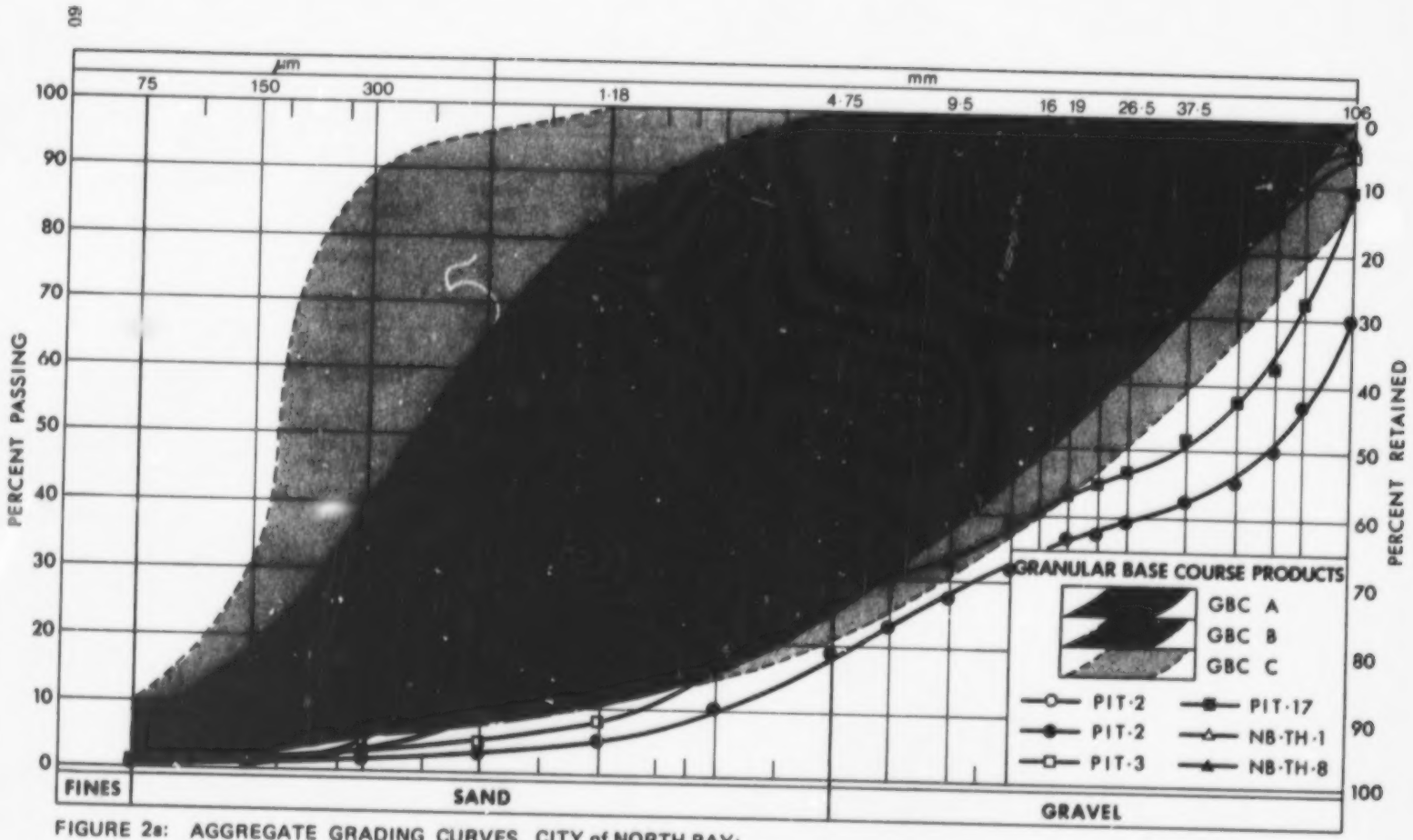


FIGURE 2a: AGGREGATE GRADING CURVES, CITY of NORTH BAY;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

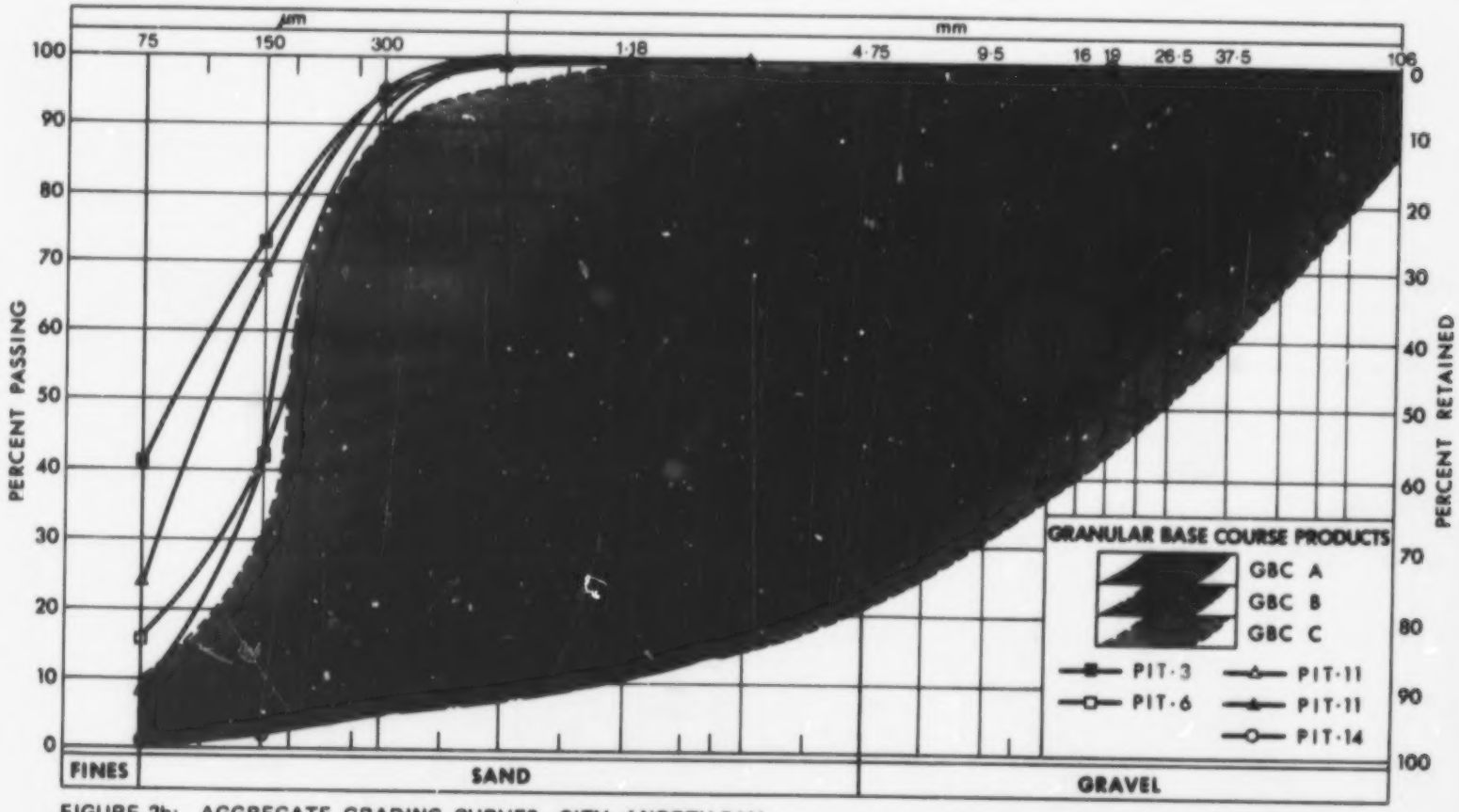


FIGURE 2b: AGGREGATE GRADING CURVES, CITY of NORTH BAY;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

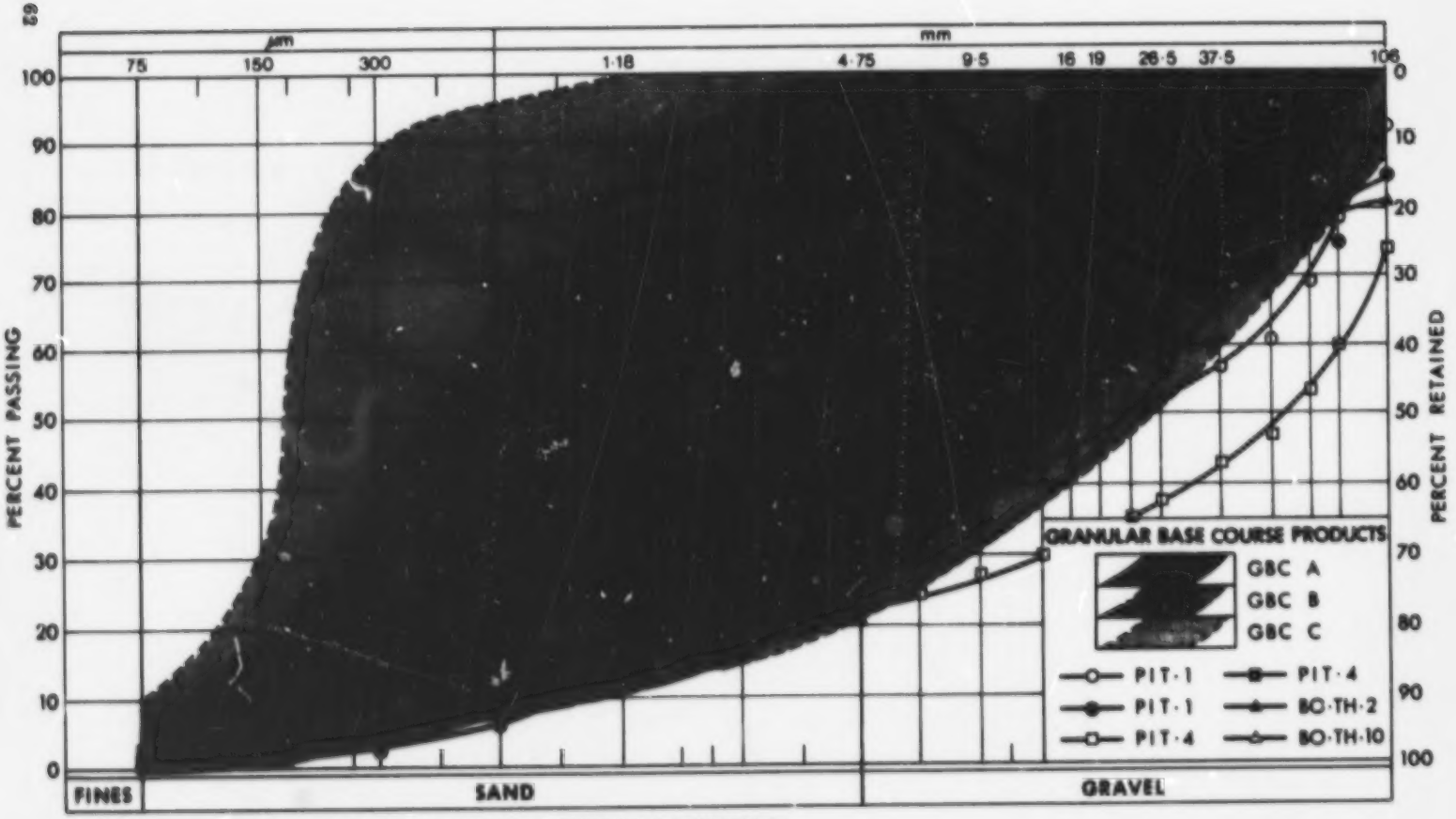


FIGURE 3a: AGGREGATE GRADING CURVES, BONFIELD TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

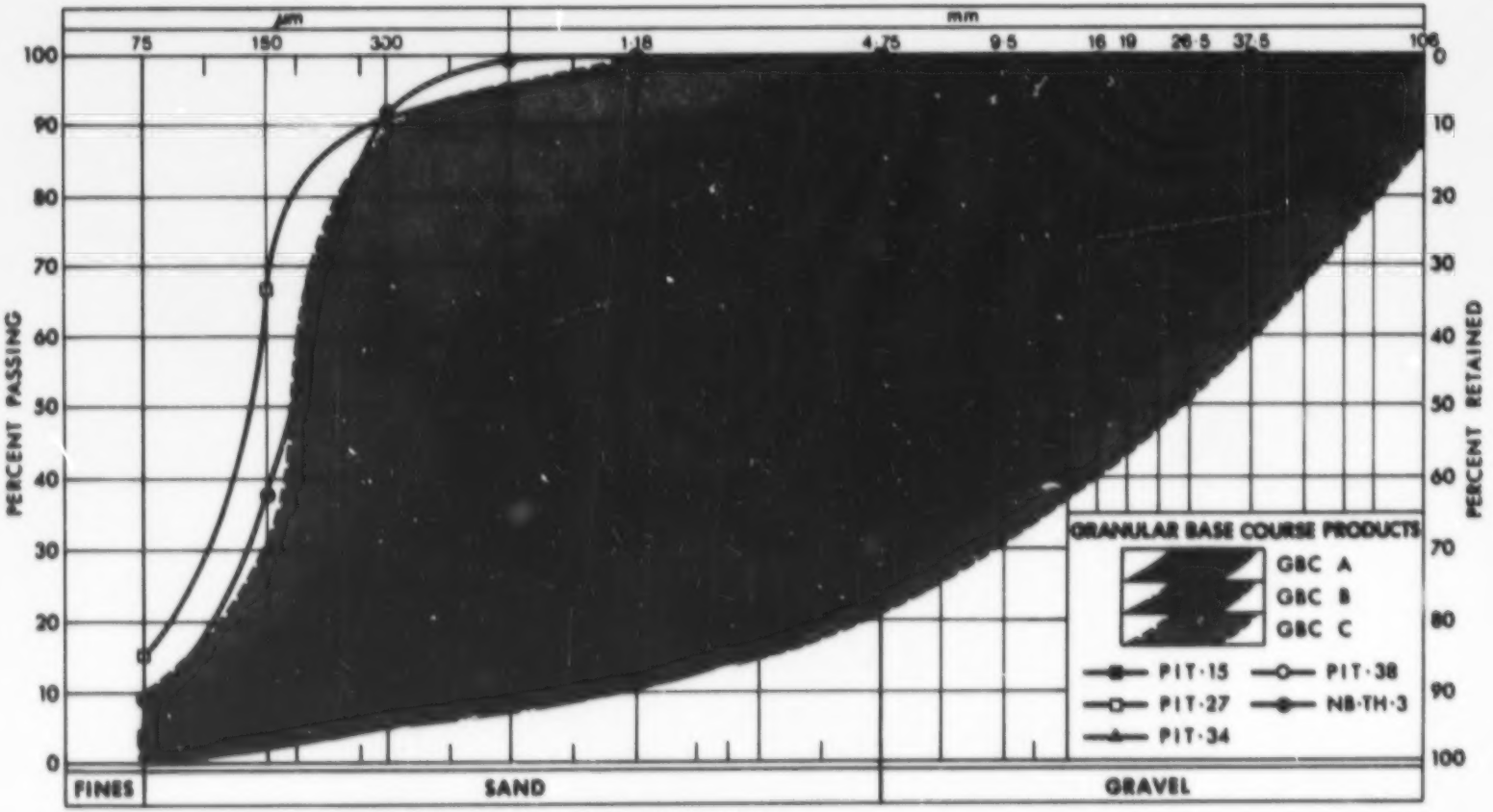


FIGURE 2c: AGGREGATE GRADING CURVES, CITY of NORTH BAY;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

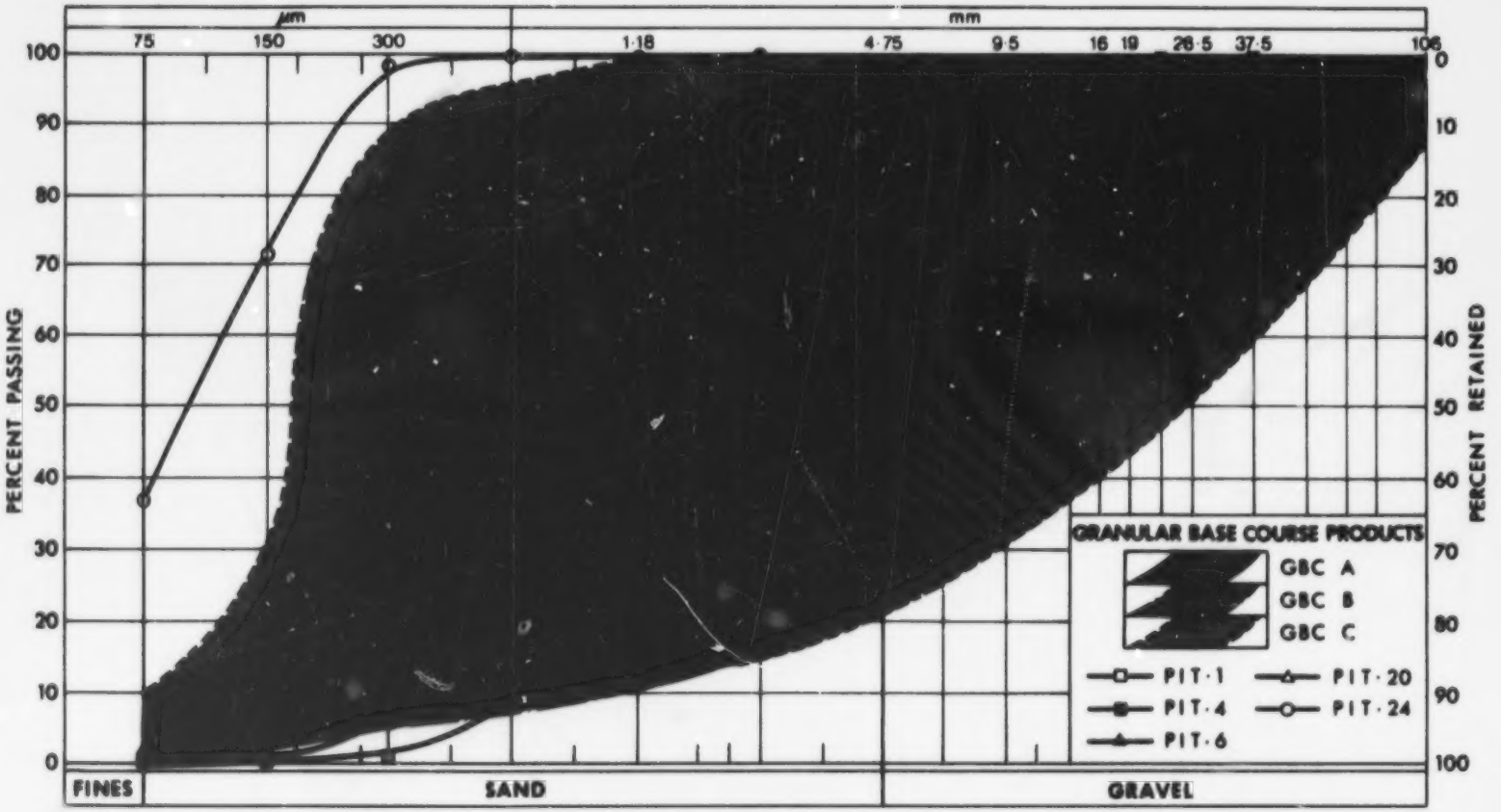


FIGURE 3b: AGGREGATE GRADING CURVES, BONFIELD TOWNSHIP:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

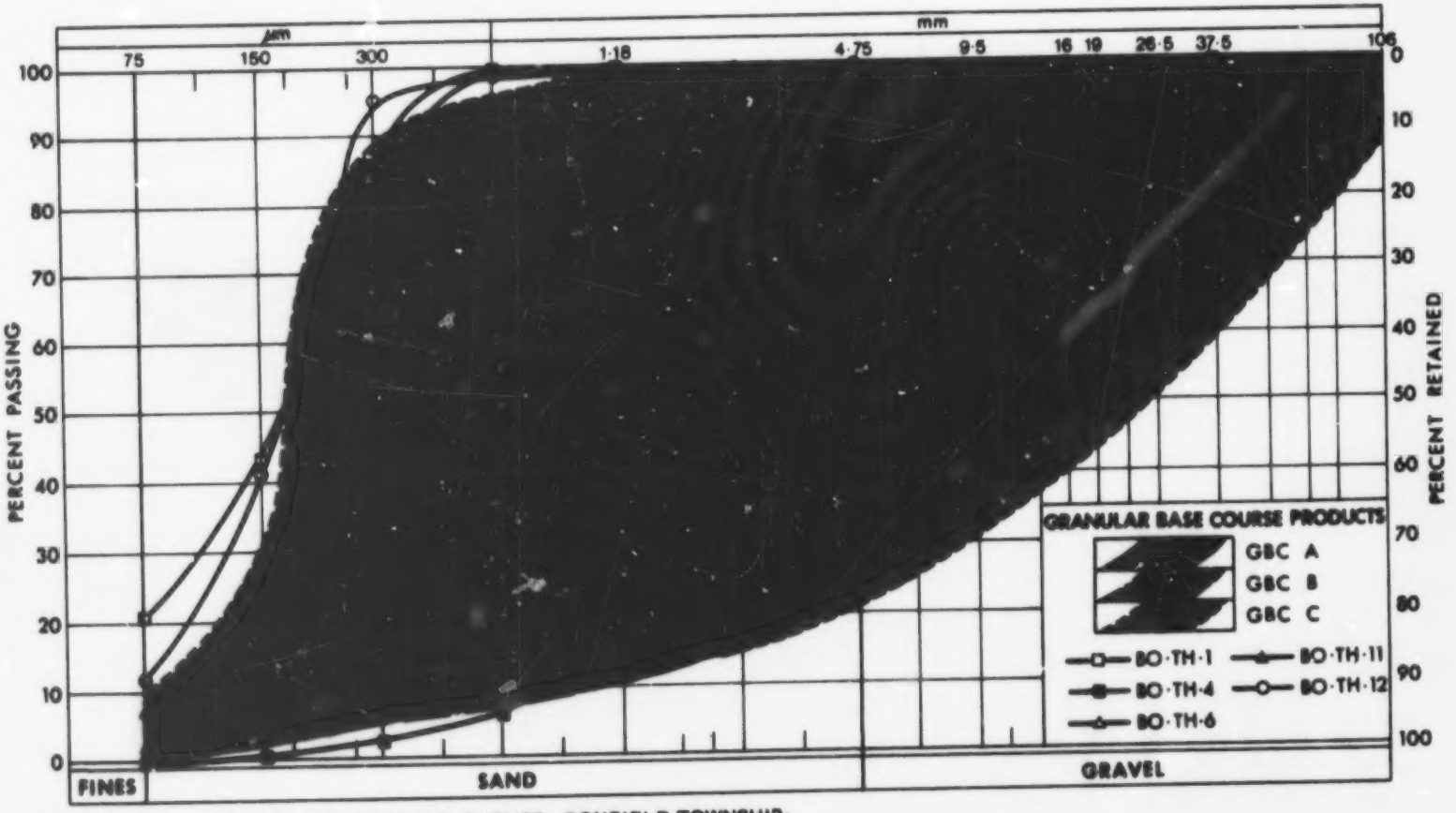


FIGURE 3c: AGGREGATE GRADING CURVES, BONFIELD TOWNSHIP.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

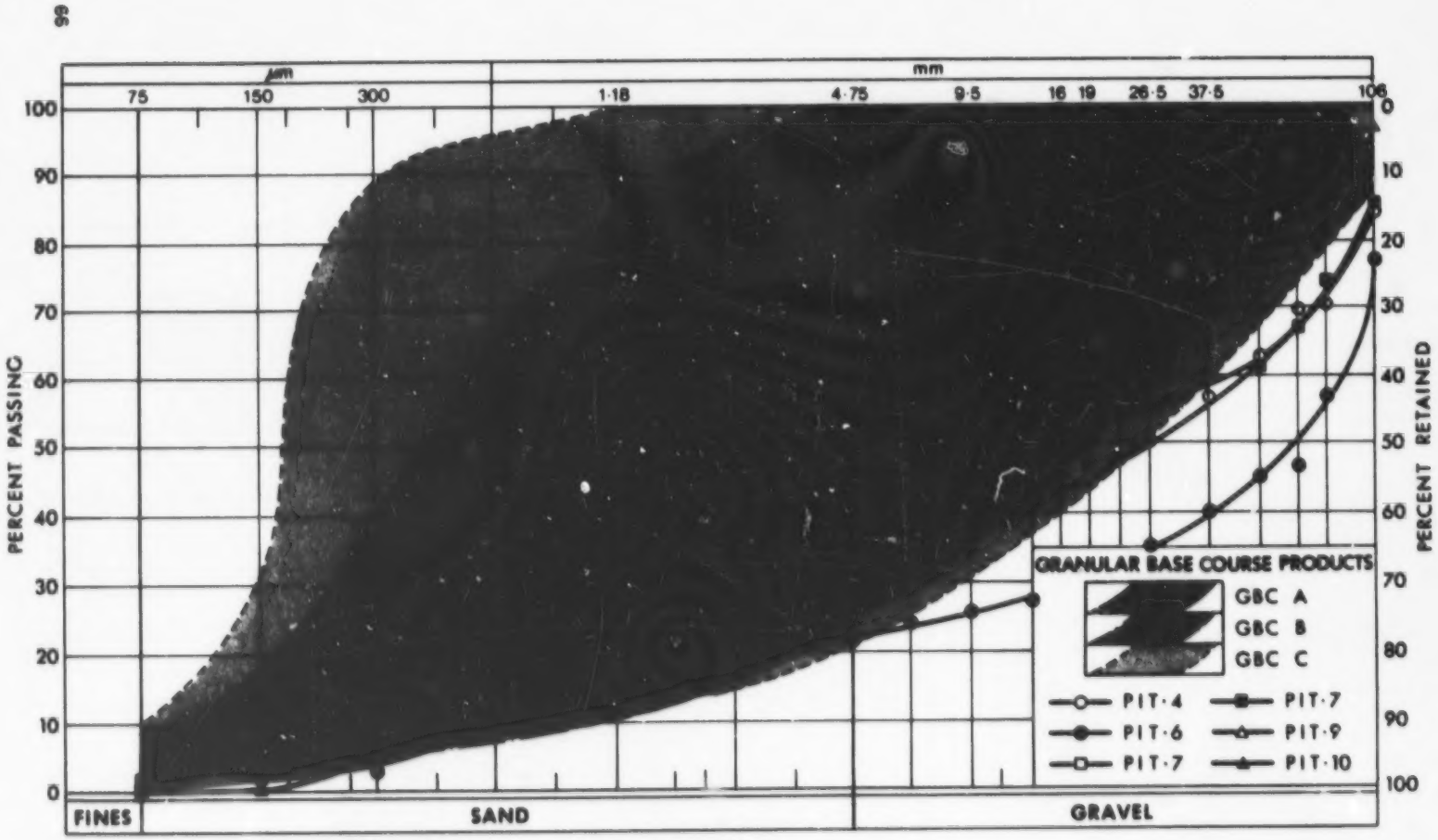


FIGURE 4a: AGGREGATE GRADING CURVES, CHISHOLM TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

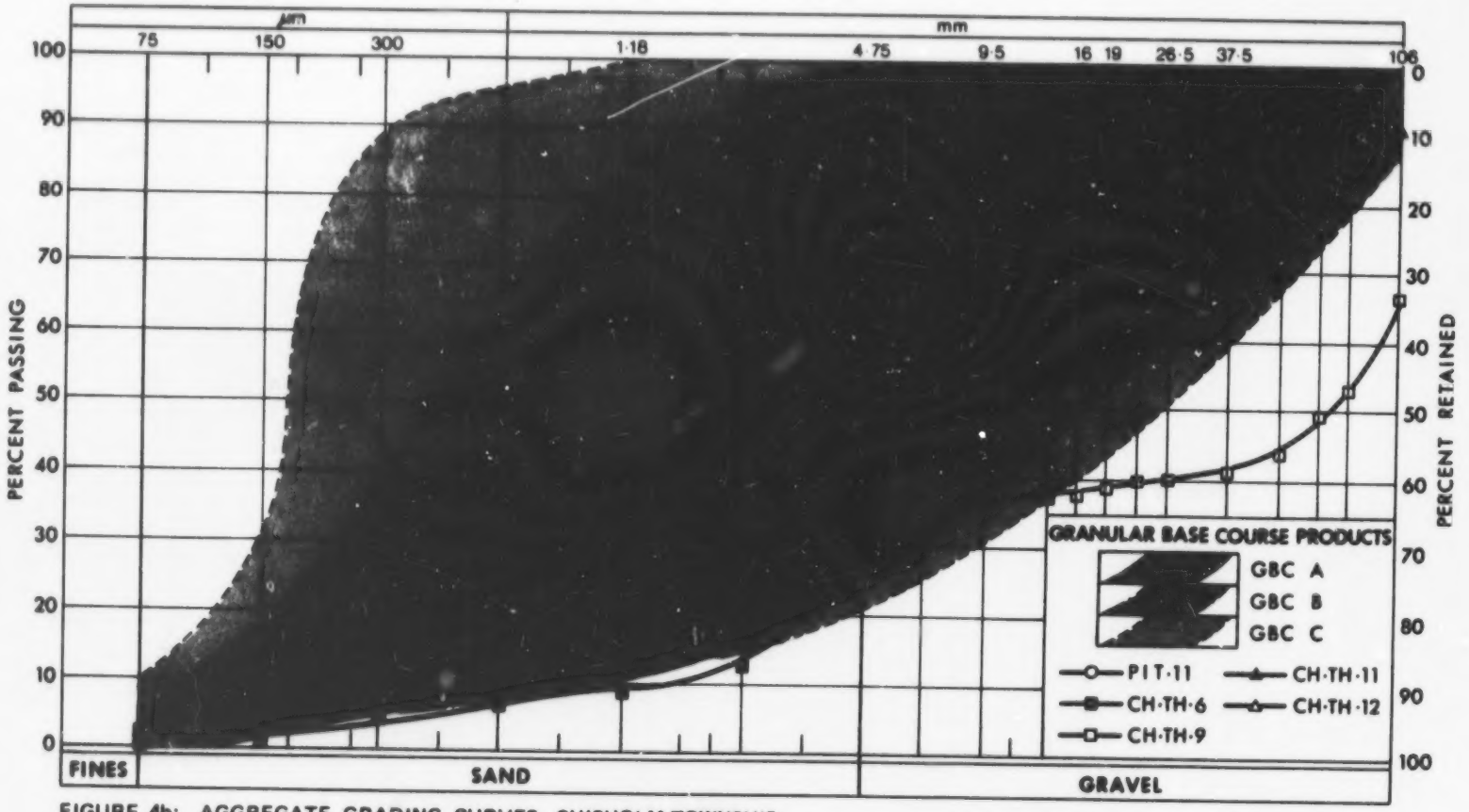


FIGURE 4b: AGGREGATE GRADING CURVES, CHISHOLM TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

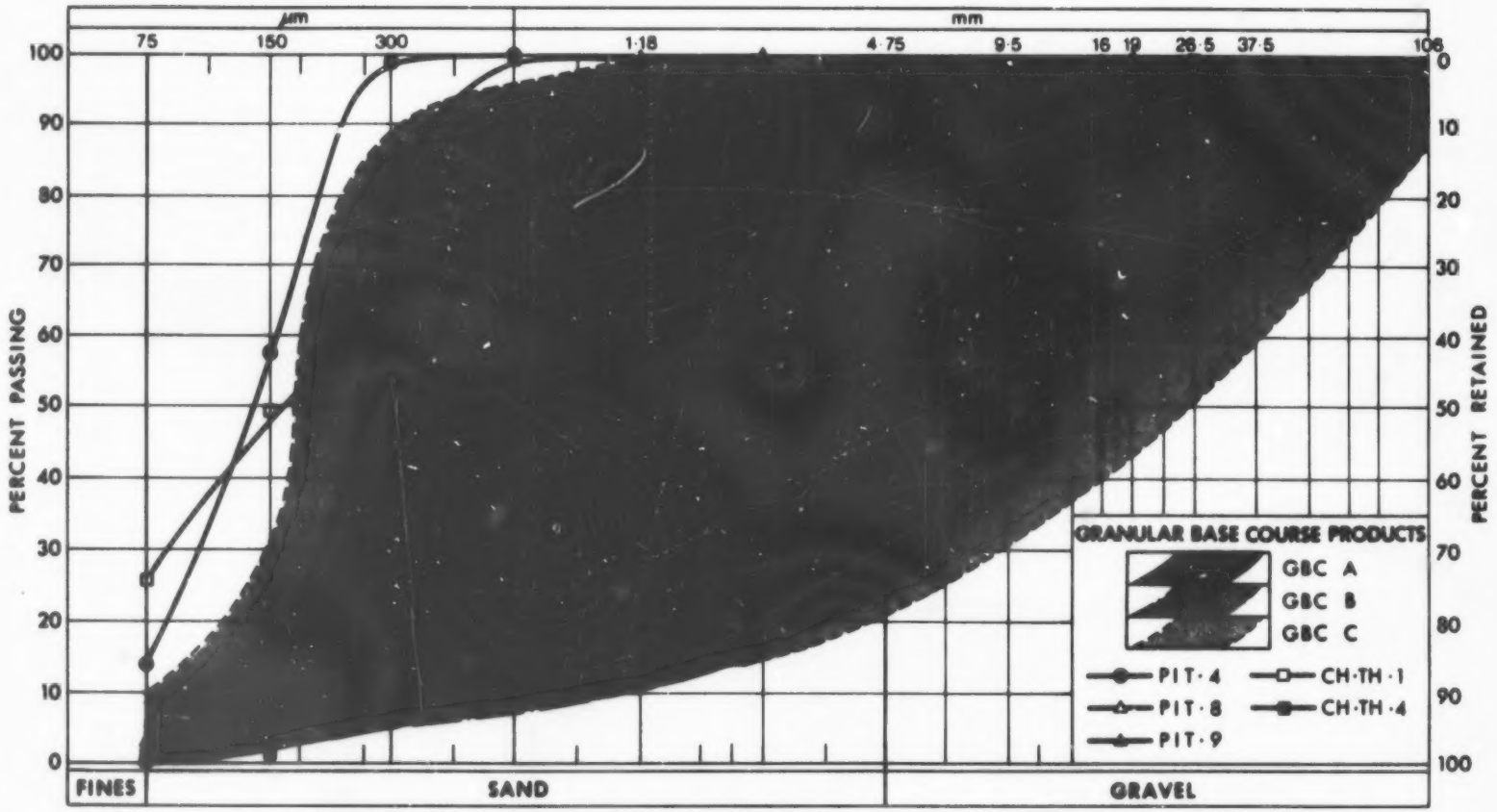


FIGURE 4c: AGGREGATE GRADING CURVES, CHISHOLM TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

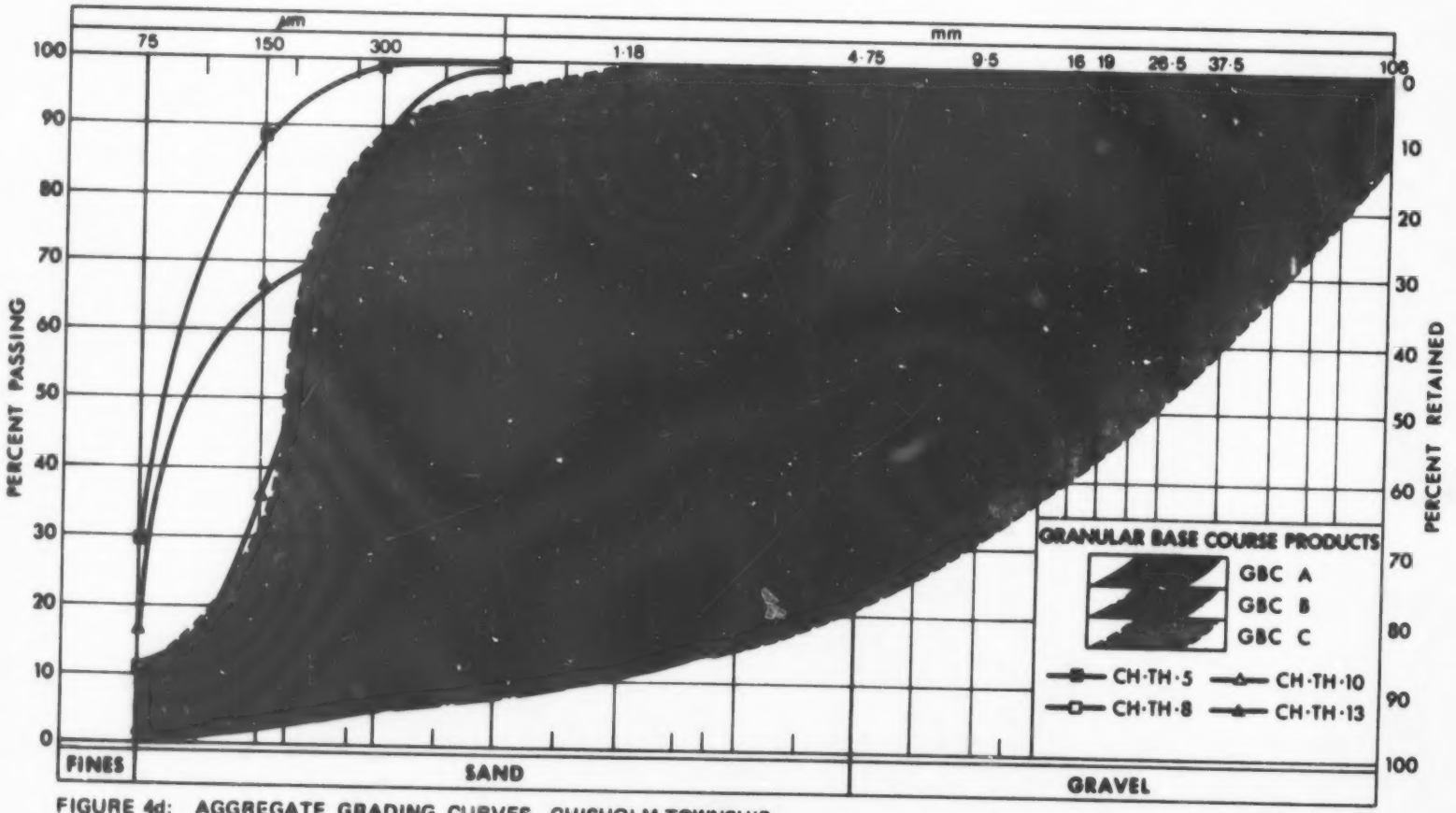


FIGURE 4d: AGGREGATE GRADING CURVES, CHISHOLM TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

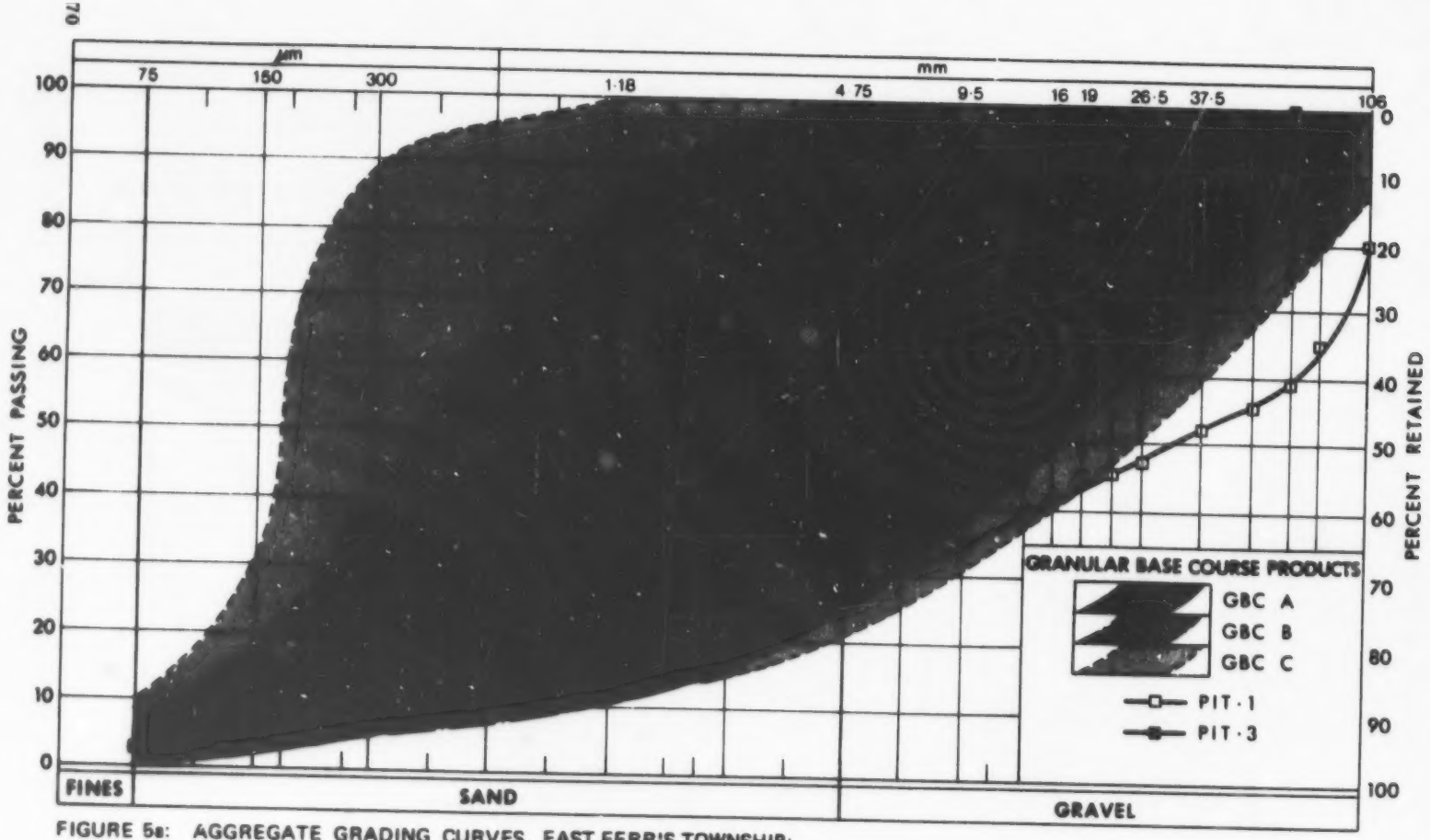


FIGURE 5a: AGGREGATE GRADING CURVES, EAST FERRIS TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

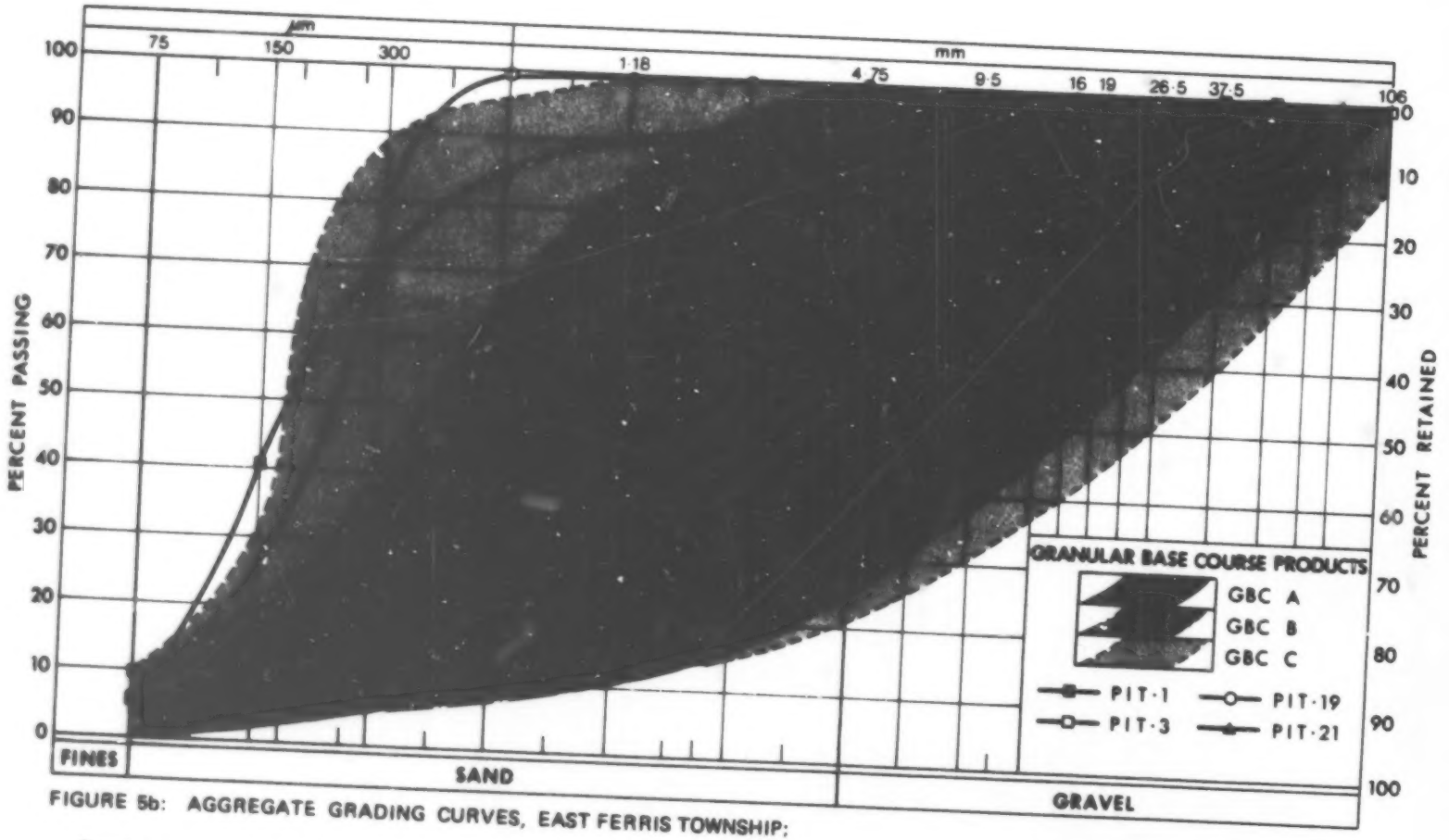


FIGURE 5b: AGGREGATE GRADING CURVES, EAST FERRIS TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

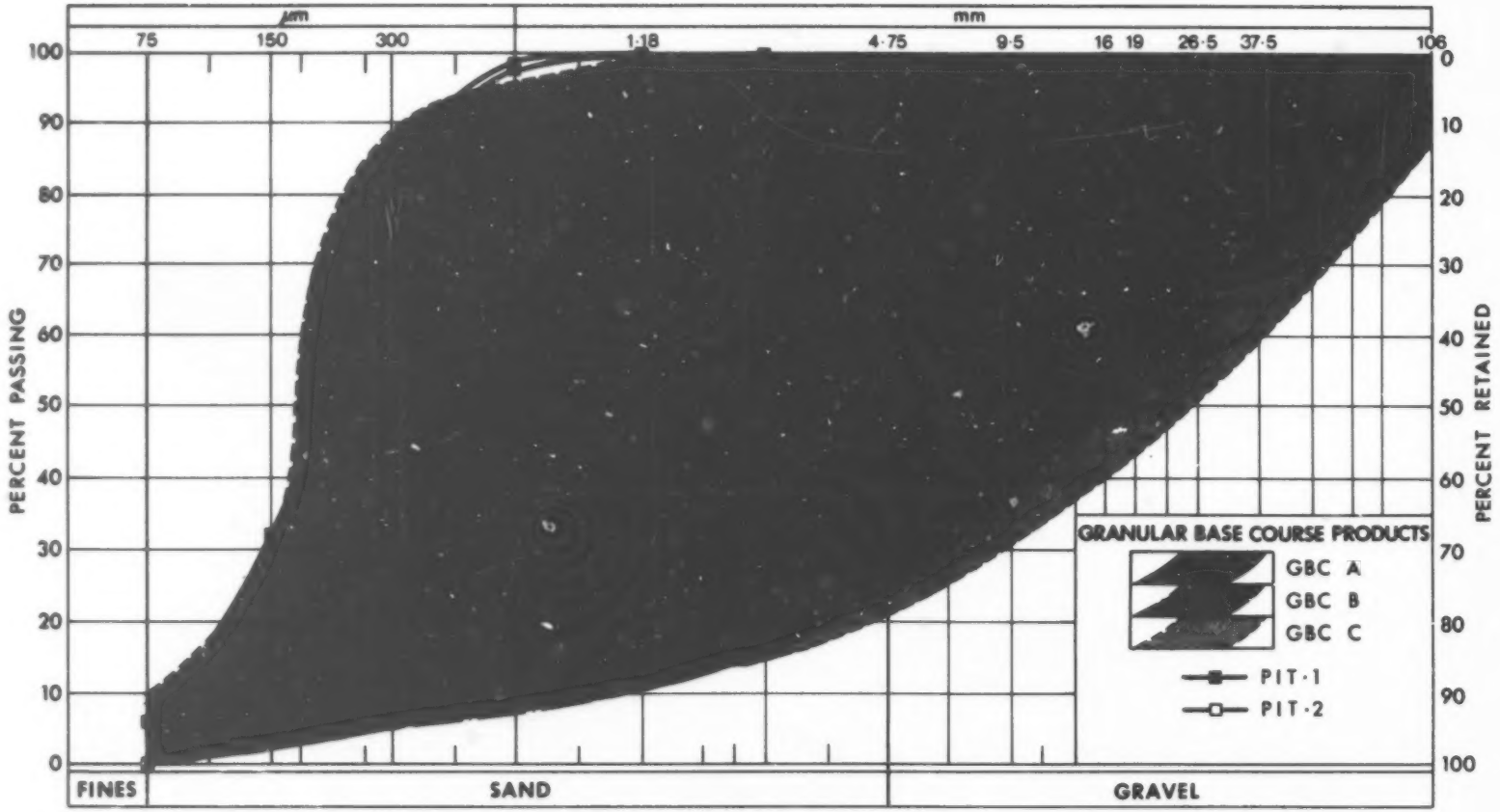


FIGURE 6: AGGREGATE GRADING CURVES, NORTH HIMSWORTH TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

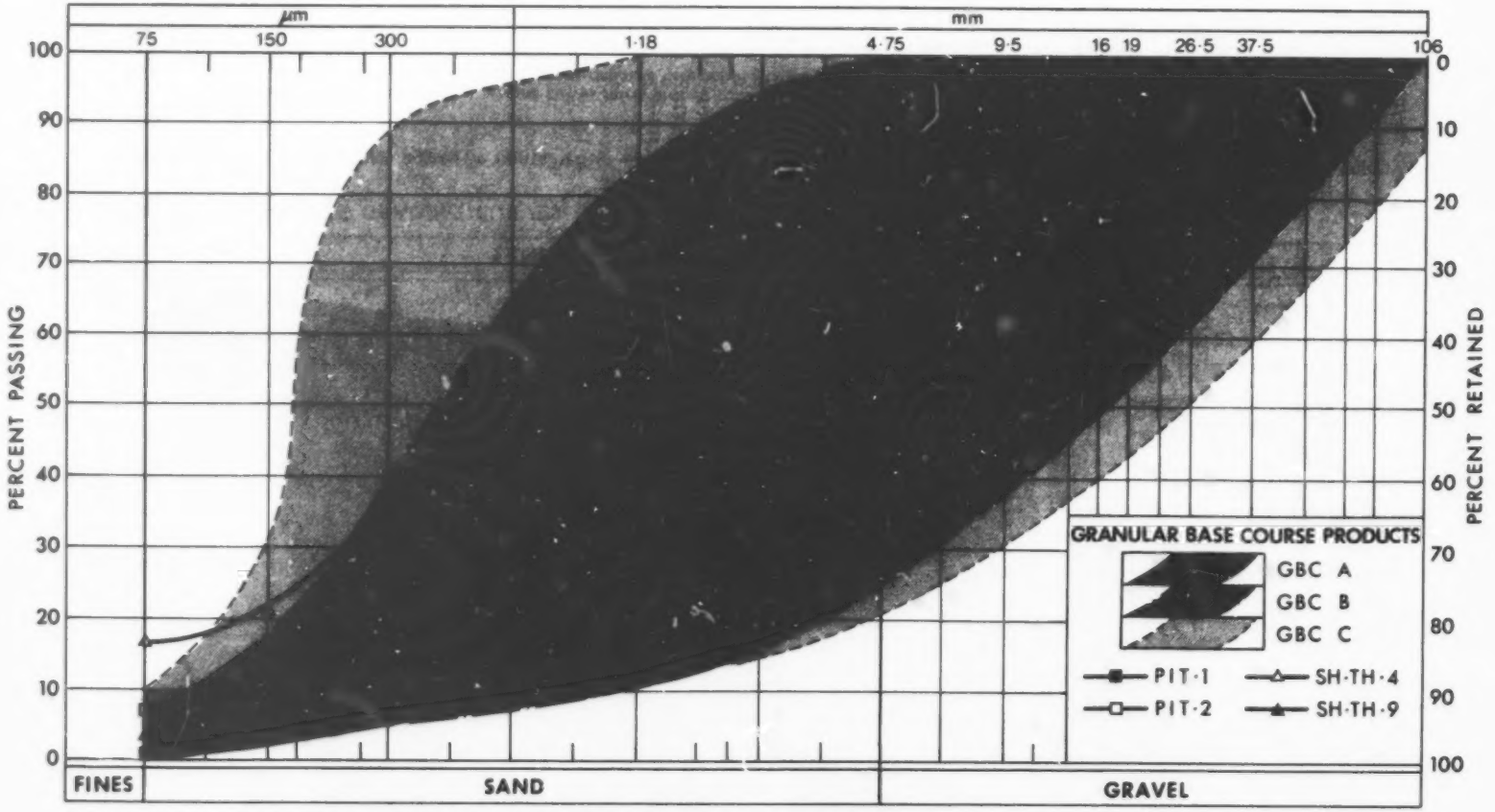


FIGURE 7a: AGGREGATE GRADING CURVES, SOUTH HIMSWORTH TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

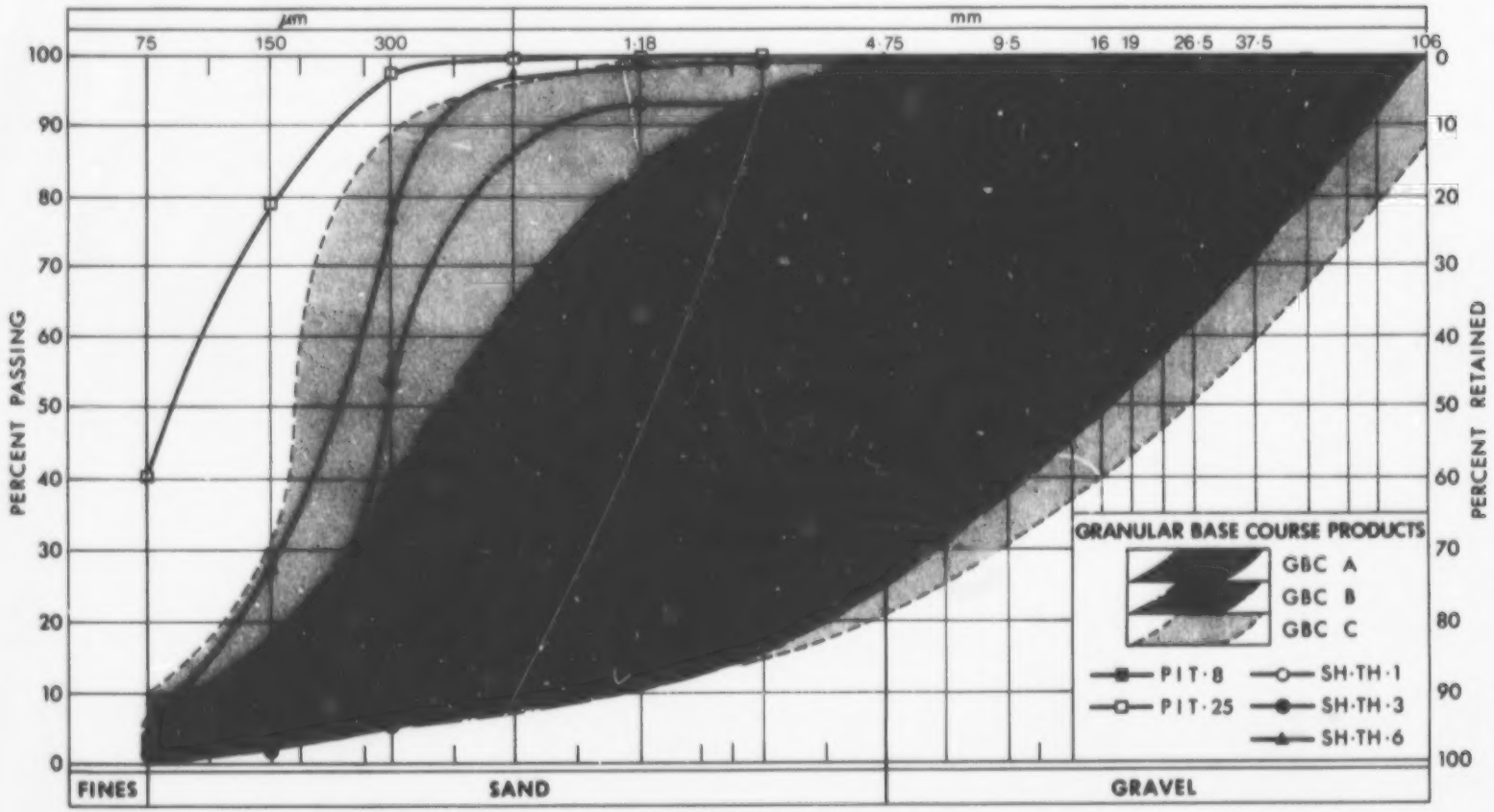


FIGURE 7b: AGGREGATE GRADING CURVES, SOUTH HIMSWORTH TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX A - SUGGESTED ADDITIONAL READING

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalies of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltatone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions. Similarly, highly weathered, very porous and friable rock can restrict the quality of the aggregate.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GNEISS

A coarse textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulders	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE

Is a coarse-grained light coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST

This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually breakdown and give high losses in this test.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of aggregate.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Estimates of mineral aggregate material based largely on broad knowledge of the geologic

character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN

The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, silstone, and mudstone.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100,000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100,000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: Those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) where detailed subsurface information is unavailable. Finer kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the glacier. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are a relatively narrow, linear feature formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D – GEOLOGY OF BEDROCK DEPOSITS (MODIFIED AFTER LUMBERS 1971)

METASEDIMENTS (Middle to Late Precambrian)

BEDROCK UNIT A Migmatitic Biotite Gneiss: is a fine- to medium-grained biotite-quartz-feldspar-gneiss containing 10 to 35 percent biotite and minor hornblende. The light to dark grey gneiss is commonly thinly bedded containing 10 percent or more of granitic veins and lenses. In places, biotite gneiss (Bedrock Unit B) may be relatively abundant within the migmatitic biotite gneiss. Minor amounts of hornblende gneiss (Bedrock Unit D) and Feldspathic gneiss (Bedrock Unit C) may also be present.

BEDROCK UNIT B Biotite Gneiss: is similar to Bedrock Unit A, except it contains less than 10 percent of granitic veins and lenses. In places migmatitic biotite gneiss may be relatively abundant within the biotite gneiss.

BEDROCK UNIT C Feldspathic Gneiss: is a fine- to medium-grained, pink to light grey foliated rock containing as much as 50 percent quartz and less than 10 percent biotite. It is interlayered with biotite gneiss (Bedrock Unit B) and migmatitic biotite gneiss (Bedrock Unit A) and in places may be kyanite bearing and migmatitic.

BEDROCK UNIT D Hornblende Gneiss: is a fine- to medium-grained, dark green to black, foliated rock with hornblende as an essential constituent. It contains discontinuous, alternating, mafic and felsic layers and consists predominantly of calc-silicate gneiss with only local lenticular masses of amphibolite. The hornblende gneiss is commonly interlayered with migmatitic biotite gneiss (Bedrock Unit A), biotite gneiss (Bedrock Unit B) and feldspathic gneiss (Bedrock Unit C). For mapping purposes these rock types have been grouped together as hornblende gneiss.

FELSIC PLUTONIC ROCKS (Middle to Late Precambrian)

BEDROCK UNIT E Monzonitic Rocks: The pink, grey and green monzonitic rocks are characterized by garnet, hornblende and biotite (and, locally, pyroxene) as the major mafic constituents and by only minor or no visible quartz. The rocks are dominantly medium to coarse grained and gneissic. Migmatitic varieties of these monzonitic rocks are virtually absent. In places, granitic rocks (Bedrock Unit F) may be relatively abundant within the monzonitic rocks.

BEDROCK UNIT F Granitic Rocks: The pinkish granitic rocks are characterized by biotite, biotite and hornblende, or less commonly by biotite and garnet as the major mafic constituents and by abundant visible quartz. They are mainly medium to coarse grained and gneissic. Migmatitic varieties of these granitic rocks are common, although hornblende-biotite granite is only slightly migmatitic. Locally, monzonitic rocks (Bedrock Unit E) may be relatively abundant within the granitic rocks.

ALKALIC AND MAFIC INTRUSIVE ROCKS

BEDROCK UNIT G Mafic Plutonic Rocks (Multiple ages represented): These rocks occur either as small rounded elongate stocks or as dikes and sills. The mafic stocks consist of medium- to coarse-grained, dark green to black metagabbro and metadiorite and minor metamorphosed ultramafic rocks. The metagabbro and metadiorite are generally foliated and gneissic. The mafic dikes and sills consist of metadiabase and fine- to medium-grained amphibolite.

BEDROCK UNIT H Alkalic and Related Mafic Intrusive Rocks (Cambrian): Most of the exposed alkalic complex rocks are fenites. The fenites are often intruded by related alkalic rocks such as nepheline syenite and carbonatite.

The complex mafic dike systems associated with the alkalic rocks consist largely of feldspar-free lamprophyric dikes. Rare basaltic and phonolitic dikes may also cut the alkalic rocks.

MAPS NOT

FILMED

CARTES

OMISES